

**ACQUIRED IMPAIRMENTS IN THEORY OF MIND AND
EXECUTIVE FUNCTION FOLLOWING STROKE**

by

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ABSTRACT

Objectives

Within the realm of social cognition, brain injury research has increasingly focussed on a specific element of social competence: the ability to attribute mental states (e.g. thoughts, feelings, desires, and beliefs) in order to explain and predict people's behaviour. This study was conducted in order to investigate this component of everyday social understanding commonly referred to as 'theory of mind' (ToM) in post-stroke individuals. The aims were to investigate whether lesions to particular areas of the brain are more detrimental to ToM ability compared to others and investigate the relationship between ToM ability and executive function following stroke.

Design

This study was of mixed factorial design and compared the performance of stroke patients (right-hemisphere stroke, $n = 15$; left-hemisphere stroke, $n = 15$) to that of controls ($n = 40$) matched for age, years of education and IQ on tasks believed to measure theory of mind and executive function.

Method

All participants were seen on one occasion and undertook psychometric testing. Information gained at these times was analysed to investigate the differences and associations between the groups' (stroke vs controls) performances on each of the measures used in this study.

Results

Significant differences were found between the groups' performances on the ToM task with results suggesting lesions to the right hemisphere as being particularly detrimental to ToM ability. Positive associations were found between performance on the ToM task and measures of executive function, although deficits in executive functioning could not fully account for the difficulties shown by stroke patients on the ToM task.

Conclusions

The findings of this study suggest that right hemisphere damage following stroke is particularly detrimental to an aspect of social cognition commonly referred to as ToM. Impaired ability to attribute mental states to others can interfere with how individuals use information conveyed through social interaction and can, in turn, affect psychosocial functioning, disrupt interpersonal relationships, and lead to reduced quality of life. The findings of this study are discussed in relation to implications for the individual and rehabilitation progress. Methodological issues, recommendations for clinical practice and future research are also discussed.

CHAPTER ONE: INTRODUCTION

1.0 INTRODUCTION

1.1 Stroke

1.1.1 Definition and Classification of Stroke

Stroke or cerebral vascular accident (CVA) is an umbrella term that includes different pathologies and clinical syndromes. It can be broadly defined as the sudden loss of blood supply to a region of the brain resulting in persistent neurological symptoms, lasting more than 24 hours, and permanent tissue damage or infarction (Robinson, 1998). As a consequence, wide-ranging disruption of function in the brain can follow depending on the area or areas of the brain affected and extent of damage incurred.

There are many ways to classify the range of disorders that are referred to as stroke. Classification of cerebrovascular disease can be based on either the cerebral vessels occluded, the cause of the vessel disease, or the means by which tissue damage occurs. Robinson (1998), however, suggests the latter classification as being the most pragmatic and outlines a classification of cerebrovascular disease based not on the aetiologies of underlying anatomical-pathological processes, which would be many and complex, but rather by using the means by which these processes manifest themselves. Using this classification system, based on the cause of tissue damage, stroke can be more simply ordered into ischaemic disorders and haemorrhagic disorders.

1.1.2 Ischaemic Stroke

Ischaemic strokes occur when one of the arteries carrying blood to the brain becomes blocked or occluded by either cerebral thrombosis or cerebral embolism. Cerebral thrombosis is the process by which a thrombus or clot forms in an artery supplying blood to the brain and can be caused by either a blood clot or a build up of atherosclerotic plaques or fatty deposits. The latter type of deposit is the most common source of obstruction of blood flow to the brain, causing 60% to 70% of all strokes and more than 75% of obstructive strokes (Bogousslavsky, Hommel, & Basetti, 1998). A thrombus is more likely to block the flow of blood if the lining of the artery has become narrowed or hardened over the years by cholesterol, a process referred to as atherosclerosis. This type of stroke is, therefore, more common in older individuals.

As a result of this atherosclerotic process, thrombotic strokes can either develop gradually, evolving for hours or days, or suddenly, with an acute presentation of neurological symptoms. The effects of this type of cerebrovascular disease can be wide-ranging from very minor to the catastrophic infarction of a large area of a particular hemisphere. More than two thirds of strokes resulting from atherosclerotic lesions involve posterior frontal, temporal, and parietal structures in the region fed by the middle cerebral artery (Neau & Bogousslavsky, 2001). When the vertebrobasilar system is involved, infarcts are commonly seen in the brainstem, inferior temporal lobe, and occipital lobes. Generally, the size of the region affected will often depend on the size of the blood vessel occluded.

Cerebral embolism is another way ischaemic stroke can occur and is due to an embolus or clot that has formed elsewhere in the body, broken away, and travelled through the blood vessels to the brain resulting in a blockage. Cerebral embolism accounts for approximately one third of all strokes (Robinson, 1998) and is most commonly caused by a piece of a thrombus breaking away within the heart and travelling up the carotid artery (see Figure 1.). The causes of thrombus formation within the heart can include cardiac arrhythmias, congenital heart disease and infectious processes. This type of stroke has the most rapid onset of all ischaemic strokes and can occur at any time without warning although, in some cases, can begin with fluctuating symptoms over the course of one or two days. Embolic strokes are often associated with heart disease, and tend to occur at an earlier age. Similar to the effects resulting from cerebral thrombosis, a large embolus may occlude a major vessel such as the internal carotid artery with more severe consequences, or, if the embolus is small in size, it may result in a transient neurological deficit. This may resolve in time as the embolus fragments and travels into smaller more distal arteries with less obvious neurological consequences.

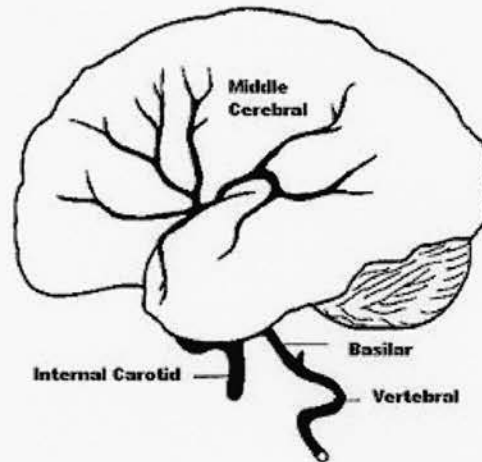
Lacunar infarctions result from occlusion of smaller penetrating cerebral arteries and account for nearly one fifth of all strokes (Robinson, 1998). Again, the effects of the occlusion of these more distal arteries depend on the brain region involved. However, they may produce no observable deficits, or be associated with pure motor or sensory deficits. There is a significant association between lacunae and both hypertension and atherosclerosis, suggesting that this type of infarction is the result of the atherosclerotic process extending into smaller vessels.

Transient Ischaemic Attacks (TIAs) or 'mini strokes' also fall within the category of ischaemic disorders and are defined as periods of transient focal ischaemia associated with reversible neurological deficits (Hennerici, Bogousslavsky & Sacco, 2004). These attacks can vary in duration from a few minutes to a few hours, up to an accepted recovery period of 24 hours (Ross-Russell, 1983). During a TIA, the individual will usually experience a sudden loss of neurological function, such as motor ability, which resolves as the clot passes to a less occluded part of the artery allowing blood flow to resume. Until recently TIAs were believed not to cause stroke. However, the development of more sophisticated imaging technology has shown that infarction to the brain can occur even when clinical symptoms have resolved rapidly (Bogousslavsky et al., 1998). TIAs are usually indicative of a thrombotic process occurring and may precede, accompany or follow the development of a full stroke.

The most frequent location for cerebral infarctions is the distribution of the middle cerebral artery. Thrombosis or emboli which occlude the large-diameter vessels on the lateral surface of the brain produce the largest lesions. Posterior circulation lesions affecting the brain stem, or penetrating arterial lesions affecting subcortical structures, usually produce small focal or lacunar lesions (Robinson, 1998).

Figure 1. Schematic lateral view of the brain showing the major arterial vessels.

The internal carotid gives rise to the anterior and middle cerebral arteries. The vertebral-basilar arteries constitute the posterior circulation including the posterior cerebral hemispheres, brain stem, cerebellum, and medial subcortical structures (Taken from Robinson, 1998).



1.1.3 Haemorrhagic Stroke

Strokes can also result from bleeding within and around the brain from a ruptured blood vessel. This type of stroke is referred to as haemorrhagic stroke of which there are two main types. The first is referred to as intracerebral haemorrhage (ICH) resulting from arterial rupture, which causes bleeding within the brain itself. There are a variety of causes, but commonly this type of stroke is associated with hypertension, or the rupture of saccular aneurysms or arteriovenous malformations (AVMs). The second is referred to as subarachnoid haemorrhage (SAH), which is caused by a ruptured vessel, usually from an aneurysm, bleeding into the subarachnoid space that surrounds the brain. The bleeding results in damage to the surrounding brain tissue, which may also be exacerbated by pressure effects causing the surrounding tissue to be either displaced or compressed if the bleeding continues. In these cases, the blood forms a mass that behaves like a space-occupying lesion.

Haemorrhagic stroke is characterised by its sudden onset. Such events are only accompanied by headache in about 50% of cases and may therefore occur with little or no prior warning signs (Bogousslavsky et al., 1998). Intracranial haemorrhage is the fourth most frequent cause of stroke and accounts for about one-seventh of all strokes (Robinson, 1998). It can be fatal in severe cases and where vital areas of the brain are affected.

1.1.4 Oxford Classification of Stroke

As stated previously, stroke can be sub-categorised in different ways. However, Bamford (1992) highlights that stroke remains a clinical diagnosis, notwithstanding the many technological advances of the past 20 years or so, and argues that for

clinicians concerned with secondary prevention, rehabilitation, and acute stroke intervention, this ‘one-stage’ diagnosis is inadequate. Clinically, subclassifications have assumed greater importance and therefore it seems prudent to briefly outline the classification system of stroke developed by Bamford and colleagues, which is commonly used in clinical settings.

Bamford and Sandercock (1991), using data from the Oxford Community Stroke project (n = 675), defined four sub-categories of cerebral infarction on the basis of presenting signs and symptoms: lacunar infarcts (LACI); total anterior circulation infarcts (TACI); partial anterior circulation infarcts (PACI); and posterior circulation infarcts (POCI). This system of classification is presented in Table 1.

Table 1. The Oxford Community Stroke Project classification of sub-types of ischaemic stroke with associated clinical features (taken from Bamford & Sandercock, 1991).

Lacunar infarct (LACI)	A pure motor stroke, a pure sensory stroke, a sensori-motor stroke, or an ataxic hemiparesis
Total anterior circulation infarcts (TACI)	A combination of new higher cerebral dysfunction (speech disturbance), homonymous visual field defect and ipsilateral motor and/or sensory deficit of at least two areas (out of face, arm and leg)
Partial anterior circulation infarcts (PACI)	Only two of the three components of a TACI, or with higher cerebral dysfunction alone, or with a motor/sensory deficit more restricted than those classified as LACI (e.g. confined to one limb)
Posterior circulation infarcts (POCI)	Any of: ipsilateral cranial nerve palsy with contralateral motor and/or sensory deficit; bilateral motor and/or sensory deficit; disorder of conjugate eye movement; cerebellar dysfunction; isolated homonymous visual field defect

While the classification is based upon bedside clinical features, the labels attached to each subcategory are anatomical, which Bamford (1992) argues reflects the close correlation between signs and symptoms and site of cerebral infarction. The advantage of using this classification is that it uses relatively simple clinical criteria. The disadvantages are that it does not extend to subarachnoid haemorrhage or intracerebral haemorrhage, and that for lacunar strokes, the relationship between clinical classification and anatomical site may not be very close (Allder, Moody, Martel et al., 2003).

1.1.5 Epidemiology

Epidemiological studies suggest that haemorrhagic strokes account for 15-20% and ischaemic strokes for 80-85% of all stroke events (Robinson, 1998). However, incidence rates are often difficult to quantify because this would require identification of all new stroke cases. Often, mild strokes go unrecognised and unevaluated, and severe strokes may result in sudden death. Immediate mortality is high, with around 1 in 5 individuals with stroke dying within 30 days (The Scottish Intercollegiate Guidelines Network (SIGN), 2002). Incidence increases significantly with age.

Stroke has a major impact on people's lives. It is the biggest cause of severe disability and a common cause of death in the United Kingdom and other developed countries. Over 100,000 people in England and Wales have a first stroke each year (BPS, 2002). The number of individuals living with stroke and its consequences in Scotland is around 70,000, with approximately 15,000 new cases estimated annually

(SIGN, 2002). The Scottish Intercollegiate Guidelines Network (2002) report stroke as being the third most common cause of death in Scotland and the most frequent cause of severe disability, with a substantial proportion of health and social care resources being devoted to the immediate and continuing care of people who have suffered a stroke (Department of Health (DoH), 2001).

1.2 Consequences of stroke

The consequences of stroke can vary significantly among individuals. As outlined above, in some individuals there may be no obvious consequences from a cerebrovascular event, while in others the extent of impairment can be catastrophic. This is primarily due to the location and extent of lesion. Factors such as age and sex are also known to influence the type of stroke experienced and the general associated physical and neuropsychological consequences (Lezak, Howieson & Loring, 2004; Damasio, Tranel, Spradling & Allinger, 1989). Wade and colleagues investigated individuals 3 weeks post stroke and reported hemiplegic limbs, communication difficulties, memory problems and perceptual deficits as being common problems amongst survivors of stroke (Wade, Langton-Hewer, Skillbeck & David, 1985).

1.2.1 Motor/Physical

Large artery strokes tend to produce significant behavioural changes. This is either due to direct damage to cortical areas or disruption of large subcortical areas. If the stroke has occurred because of obstruction of smaller arteries then fewer behavioural changes may be seen. The degree of impairment is also directly related to the location and extent of lesion, and as stated above, can vary greatly among

individuals. However, despite these variations, there are patterns of deficits that are common. One of the most frequent problems after stroke is motor dysfunction. Weakness, heaviness or paralysis down one side of the body is apparent, contralateral to the side of lesion. This may affect an arm or leg, the face, or the whole of one side of the body. Swallowing difficulties or dysphagia, loss of bladder and/or bowel control and somatosensory changes are also common. These motor difficulties can be very pronounced at time of onset and during the early course of recovery, but as swelling reduces in the brain and other physiological secondary effects of the stroke return to normal, the concomitant impairments also usually decrease (Hennerici et al., 2004).

1.2.2 Cognition

Besides physical handicaps, cognitive disorders following stroke can also contribute to disability in every day life (McKinlay & Brooks, 1984) and usually result from damage to the forebrain regions.

Stroke has been found to lead to specific cognitive deficits such as aphasia, apraxia, and neglect, but also affects general cognitive functions such as memory, attention and executive functioning (Hochstenbach, Mulder, van Limbeek et al., 1998; Rasquin, Verhey, Lousberg et al., 2002; Stephens, Kenny, Rowan et al., 2004). Variations in presentation of cognitive deficits are also seen depending on which hemisphere of the brain has been damaged. The most obvious cognitive disorders for those individuals with right-sided damage involve visuospatial abilities and gestalt-type concept formation (Lezak et al., 2004). Left-sided visual neglect, often

viewed as being characteristic of stroke, is also common following right-sided stroke. For example, Heir, Mondlock and Caplan (1983) found that 85% of the 41 individuals in their study with right-sided stroke displayed signs of left-sided neglect. In contrast, disorders of language, such as aphasia, are commonly seen in stroke patients with left-sided damage to the brain (Lezak et al., 2004; Clarke, 2001). Factors other than location of lesion have also been found to predict cognitive impairment following stroke. In a study conducted by Rasquin and colleagues (n = 176), older age and low educational level were found to be predictors of cognitive disorders in post-stroke survivors (Rasquin, Verhey, van Oostenbrugge et al., 2004b).

In addition to the cognitive deficits that can be quite pronounced following stroke, such as aphasia and neglect, mild cognitive impairments are also common. For example, Rasquin, Lodder and Ponds et al. (2004a) investigated the frequency of post-stroke mild cognitive impairment (MCI) and its clinical course after first-ever stroke in a sample of 196 patients (mean age 68). These authors found the frequency of post-stroke MCI to be high, with almost 65% of patients experiencing multiple cognitive deficits, with mental speed and calculation reported as the most frequently disturbed cognitive functions. Rasquin et al., (2004a) concluded that whilst most patients were found to have MCI, improvement of cognitive function was seen at 6 and 12 months follow-up. However, they highlighted that some patients did not show improvement in all domains investigated.

Despite individuals often experiencing wide-ranging deficits in cognitive functioning following stroke, subjective data on changes after stroke showed that patients and

their relatives' rated mental slowness first on a list of cognitive complaints (Hochstenbach et al. 1998). This is in keeping with results found by Rasquin et al. (2004a) and suggests that mental slowness is a common consequence of stroke.

Gerritsen, Berg, and Deelman et al. (2003) investigated speed of information processing following stroke. They studied 42 right and 46 left hemisphere first-ever stroke patients and compared their performance to 71 healthy controls on reaction time tasks with different levels of complexity. Gerritsen and colleagues found that stroke caused a decrease in decision making speed, and differential effects of right (RHD) and left hemisphere damage (LHD). The right hemisphere group were slower than the control participants, and slower than the left hemisphere group on all tasks. LHD patients were slower than the controls only on the most complex tasks.

Similarly, Hochstenbach, Mulder and Limbeek et al. (1998) investigated the performance of 229 (140 males, 89 women) patients who had suffered a stroke using an extensive neuropsychological battery of tests. These authors found more than 70% of individuals showed marked slowness of information processing. At least 40% of all patients had difficulty with memory, visuospatial and constructive tasks, language skills, and arithmetic. Further analyses revealed that performance was better after right-sided lesions than after left-sided lesions, with the exception of visuospatial tasks. However, details were not provided with regards to the numbers in each of the stroke groups (left versus right sided lesion) and many of the tasks had a high verbal component. Presumably this would have greatly affected those individuals with left-sided lesions, given that the left hemisphere is typically dominant for language.

As outlined above, the severity and type of cognitive impairments following stroke can vary significantly amongst individuals and can disrupt processes central to social interaction and communication. These include language, visual perception, attention and memory difficulties. A high incidence of mild cognitive impairments has also been found. As such, Riepe and colleagues advocate formal brief cognitive screening for all stroke patients (Riepe, Riss, Bittner & Huber, 2004).

1.2.3 Affect

Mood disorders following stroke are common (estimates of between 25 to 50 per cent) and are associated with symptoms such as withdrawal, apathy and irritability (Robinson, 1998). Robinson (1998) describes depression as one of the most frequent emotional disorders experienced by stroke survivors that has an impact on rehabilitation outcome and recovery. One of the first studies to examine post-stroke mood disorders was conducted by Folstein, Maiberger, and McHugh (1977). These authors found that stroke patients were more frequently depressed than patients with orthopaedic problems who had comparable physical impairments. Since then, disorders of affect following stroke have continued to be studied extensively, although the prevalence of post-stroke depression varies depending upon the population being studied. Based on a community sample ($n = 379$), Wade, Legh-Smith and Hower (1987) found that 3 weeks after stroke 22% of patients were depressed using a cut-off score on the Wakefield Inventory. The prevalence of depression in hospitalised patients with acute stroke has been found to be similar to that found in outpatient samples (Robinson, Starr, Kubos, & Price, 1983). Among a consecutive series of patients admitted to a rehabilitation hospital, Sinyor, Amato and

Kaloupek (1987) reported prevalence rates for mild, moderate, and severe depression as 17%, 23%, and 9% respectively. Piamarta and colleagues (2004) examined affective symptoms in the early post-stroke period (age range 60-88) and found moderate associations between apathy and both executive functions and mood levels (Piamarta, Iurlaro, Isella et al., 2004).

There are mixed findings reported in the literature regarding the role that each of the hemispheres play in depression following brain injury. Some studies report that depression after stroke is the result of left-hemisphere lesions (Robinson, et al., 1984), whereas other studies report a greater incidence of depression after right-hemisphere lesions (Dam, Pederson, & Ahlgren, 1989). Depression is also a frequent finding in patients with frontal lobe lesions (Starkstein & Robinson, 1991). However, despite these findings, it is clear that depression may also occur as a psychological reaction to a catastrophic life event.

Anxiety is another emotional disorder commonly seen following stroke and is associated with physiological arousal, verbal reports of feelings of distress, and overt avoidance behaviour (Robinson, 1998). Approximately 25-50% of patients have been found to present with anxiety disorders in the acute phase of stroke, whereas the prevalence is slightly less at one year and a 3 years follow-up (Astrom, Adolfsson, & Asplund, 1993). Similar to depression, existing data about the relationship of anxiety with the location of lesion are not conclusive (Carota, Staub, & Bogousslavsky, 2002).

These findings suggest that anxiety and depression are frequently associated with stroke and have been shown to impact on recovery rates and rehabilitation outcomes. Because of their nature, these types of affective disorders are also very likely to impact on residual cognitive functioning, psychosocial functioning, and the individual's quality of life.

1.2.4 Emotion

In addition to causing physical and cognitive impairments and changes in affect, stroke can cause changes in the way stroke patients express, experience or comprehend emotions (Elinger, Parkinson & Shamay, 2002; Bogousslavsky, 2003). Such emotion-related processing disorders can interfere with how individuals use emotional information conveyed through social interaction and can, in turn, affect psychosocial functioning (Eslinger et al., 2002). The kinds of emotional disorders associated with stroke may range from depression (see section 1.2.3) to personality change with irritability, apathy, or emotional withdrawal (Robinson, 1998).

Emotional lability or 'emotionalism' is also characteristic of stroke, particularly following damage to the right hemisphere (Rolls, 1999). This phenomenon of crying or laughing out of proportion to the underlying feelings of sadness or happiness can start with little or no warning and can therefore be a source of embarrassment to the individual. It can also lead to withdrawal from social situations. A review conducted by Carota et al. (2002) reported that emotional lability is frequent in acute stroke (40%), at one month post stroke (21%), but shows a decline over the first 6 months (15-21%). Several studies have found a consistent prevalence of

approximately 20% of patients experiencing pathological laughing or crying at some time during the first year following stroke (Anderson, 1995; House, Dennis & Molyneau et al., 1989).

Neuroanatomical structures related to emotion have been identified at different levels of the nervous system, including cortical, subcortical and limbic areas. The most common sites of cerebrovascular disease affecting emotion-related processing are the right hemisphere and frontal lobe (Zgaljardic, Borod & Sliwinski, 2002); Borod, Andelman, Obler et al., 1992). These regions encompass neocortical as well as paralimbic structures that sub-serve different aspects of emotional communication. Current models of emotion and the brain emphasise a vital role for the posterior right hemisphere and amygdala in the accurate perception of emotional stimuli, such as prosody (inflections of voice) and emotional facial expressions, and for the frontal lobe in the regulation and expression of emotion (Carota et al. 2002). The left hemisphere is normally viewed as dealing with the verbal content of emotional stimuli. Damage to the thalamic regions of the brain can lead to a reduction in emotional capacity and responsiveness, including flat affect and apathy (Butters & Stuss, 1989). However, transient manic type episodes have been reported in individuals with right thalamic lesions (Cummings & Mendez, 1984).

The above research findings demonstrate that there are a number of factors that influence emotional functioning after stroke. These include the location of lesion and the mode of the emotional stimuli. It is also understandable how these kinds of difficulties can interfere with social functioning following stroke.

1.2.5 Recovery of Function and Rehabilitation

Recovery from stroke depends on many different factors including the location and extent of the lesion, a person's age, and their general health before the stroke. If no further stroke occurs, there are usually significant spontaneous improvements in both physical and mental functioning, although again this can be variable. This is primarily due to the reduction in swelling of the brain around the site of stroke allowing some of the affected cells to recover their function (Marciano, Green, & Stachowiak, 1992).

In addition to this process of spontaneous recovery, there is also strong evidence that stroke rehabilitation improves functional outcome and enhances quality of life (Jeffrey & Good, 1995; Scottish Intercollegiate Guidelines Network (SIGN), 2002). However, anosognosia (lack of awareness) has been shown to have a detrimental effect on rehabilitation progress and hence recovery. Anosognosia is defined as the partial or complete unawareness of a deficit and can be inconsistent across physical, cognitive and affective domains. Hartmann-Maeir, Soroker, Ring, and Katz (2002) investigated the awareness of deficit profiles of stroke patients (n = 60; right-sided lesion, n = 36, and left-sided lesion, n = 24) undergoing rehabilitation and examined the impact of unawareness on rehabilitation functional outcomes. These authors reported that the frequency of unawareness for motor and sensory deficits was low, whereas unawareness of cognitive deficits much higher. The results also indicated that unawareness at admission to rehabilitation in the right-hemisphere damaged group was a detrimental factor in achieving independence in basic activities of daily living functions (ADLs).

Hochstenbach et al. (2003) compiled an inventory of emotional and cognitive changes reported by patients (n = 65) and significant others 9 months after stroke onset. These authors concluded that emotional and cognitive changes following stroke are experienced by 50% of stroke patients and their relatives. Most frequently mentioned changes by patients and partners, irrespective of side of lesion, were mental slowness, memory disabilities, less initiative and emotional lability. However, agreement between patients and relatives was low and one of the relevant patient-related factors was the amount of awareness of deficits the patient displayed.

Several studies have found that impaired awareness of deficits following brain injury is more commonly associated with right-sided stroke (Giacino and Cicerone, 1998; Starkstein, Federoff, Price, Leiguarda & Robinson, 1992). More specifically, McGlynn and Schacter (1989) suggest that unawareness of perceptual and motor deficits involves parietal damage, while unawareness of complex deficits such as cognitive and behavioural changes involves frontal damage.

As outlined in section 1.2.2, cognitive deficits can also have a detrimental effect on recovery. Galski, Bruno, Zorowitz and Walker (1993) studied 36 patients after stroke and found that higher cognitive impairments involving comprehension judgement, short-term verbal memory and abstract thinking were of primary importance in extending the length of stay in hospital. Higher cognitive impairments also necessitated the need for outpatient and home services after discharge. Similarly, Zinn and colleagues also found that cognitive impairments affect recovery of independent ADLs (Zinn, Dudley & Hayden et al., 2004).

Although it may be debated whether physical, cognitive or emotional impairments are the most frequent and devastating consequence of stroke, a high proportion of patients must cope with serious permanent cognitive decline (Hochstenbach, den Otter, & Mulder, 2003; Patel, Coshall, Rudd, & Wolfe, 2003). In addition, there is an abundance of evidence that shows emotional disorders constitute one of the major obstacles to recovery and to achieving maximal quality of life following stroke (see sections 1.2.3 and 1.2.4). Remarkably, however, many of the policy documents, guidelines, and rehabilitation research have tended to focus on physical or motor aspects of stroke. More recently the cognitive and affective consequences of stroke have been highlighted, with emphasis being placed on the implications for assessment and rehabilitation process if these are not addressed. Relatively little attention has been paid however to the emotional or social functioning problems which occur in stroke patients.

1.3 Executive Function

The frontal lobes of the brain play an essential role in behaviour, cognition and emotion. Therefore damage to these structures can result in a variety of difficulties in a number of areas of functioning, such as language, executive functions, and social functioning (Lezak et al., 2004). In particular, the frontal lobes have been found to be implicated in distinctive 'frontal' syndromes, predominantly following damage to the pre-frontal, medial-frontal and orbito-frontal areas (Robinson, 1998; Wilson et al., 1996). Individuals with damage to these areas can display difficulties with inhibition, impulsivity and social inappropriateness amongst others.

One of the most famous cases of injury to the frontal lobes was that of Phineus Gage. He was reported in 1878 to have survived an explosion that blasted an iron bar upwards through his left frontal lobe, and to have no gross neurological disability as a consequence (Damasio, Grabowski, Frank, Galaburda, & Damasio, 1994). The angle at which the iron bar entered Gage's skull however meant that he probably sustained additional injury to the right frontal region of the cortex. Following the trauma, marked personality and behavioural changes were noted. The clinical presentation was one of disinhibited, irritable behaviour as well as a lack of drive and motivation. He was also reported as showing poor judgement, using obscene language and being inconsiderate towards others. These behavioural changes were in direct contrast to how he was reported to have behaved prior to his accident. This case highlights that the frontal lobes subserve a range of cognitive and behavioural functions, and that specific damage to these areas can result in profound personality and behavioural changes.

Regions of the frontal cortex have been shown to have multiple reciprocal connections with subcortical structures including the basal ganglia, midbrain, and pons, and individuals with damage to these structures have also been found to display similar difficulties to those outlined above (Grafman, Sirigu, Spector & Hendler, 1993). Thus, damage to subcortical structures or disruption in these interconnections or systems can present as 'frontal' symptomatology, in the absence of specific damage to the frontal lobes (Benton, 1991). This suggests that the frontal lobes, in addition to having a specific significance to given cognitive functions, are also part of a wider neural network that incorporates subcortical structures.

Throughout the literature terms such as 'frontal functioning' and 'executive functioning' are used interchangeably to denote the wide-ranging cognitive functions and behaviours associated with the frontal lobes (Stuss & Benson, 1986). However, the findings highlighted above suggest this may be somewhat misleading. In addition, Phillips (1997) highlights the many difficulties with considering executive function as being analogous to frontal functioning. Individuals with lesions that do not involve the frontal lobes have been found to perform poorly on tests of executive functioning and, conversely, individuals with frontal lobe lesions have been found to perform within the normal range on these tasks. Therefore, the term executive function will be used in this piece of work and more clearly defined below.

According to Burgess and Shallice (1997), executive functions refer to the high-level cognitive processes that underlie flexible goal-directed behaviour. These include processes such as goal selection, planning, monitoring, sequencing, and other supervisory processes, which permit the individual to impose organisation and structure upon his or her environment. In other words, executive functioning underlies how behaviour is expressed (Lezak et al., 2004).

Executive functioning is viewed as being closely linked to a range of cognitive functions. However, Lezak et al. (2004) highlight executive functions differ from cognitive functions in an important way. Impairments in executive functions tend to have a more global impact affecting all aspects of behaviour, regardless of whether specific cognitive abilities remain relatively intact. Whereas when executive functions are intact, an individual can sustain considerable cognitive loss. This may

be why executive functioning has been viewed by many as analogous to the conductor of an orchestra; it has an influence that is greater than the sum of its component parts.

Evidence from neuropsychological and functional imaging studies suggests that different aspects of executive functions are dissociable and are mediated by distinct neural systems subserved by different regions of the prefrontal cortex (Burgess & Shallice, 1997; Damasio, 1998). This may account for the multiple and varied behavioural changes seen when executive functioning is impaired, and for the variability between individuals. However, executive functioning deficits are commonly associated with personality change, cognitive deficits in specific domains, and altered psychosocial and emotional functioning.

In addition to localised lesions accounting for deficits in executive functioning, there is also evidence indicating that the prefrontal cortex undergoes a marked deterioration as a function of normal ageing. Mittenberg, Seidenberg, O'Leary, and DiGiulio (1989) gave a neuropsychological test battery to people of varying ages (20-75 years) and found that the strongest correlations were between age and measures of frontal performance. This suggests that reduced executive functioning performance may result from the normal ageing process as well as from specific lesions in the frontal lobes and connected structures.

1.3.1 Executive Function and Stroke

The executive functions are highly sensitive to brain damage and executive dysfunction is therefore the most common presenting problem in neuropsychological practice (Stuss & Levine, 2002). In cases of neurological pathology, a number of researchers have documented deficits in executive functioning following damage to the frontal lobes, such as cerebrovascular disease, as well as lesions following traumatic brain injury (e.g. Della Sala, Gray, Spinnler, & Traveli, 1998). Executive impairments have also been found to be particularly important in determining rehabilitation and psychosocial outcomes (Crepeau & Scherzer, 1993; Vilkki, Ahola, Holst et al., 1994). Therefore, it is highly likely that a significant proportion of individuals in post-stroke rehabilitation wards will experience a range of difficulties associated with impairments in this area of cognitive functioning.

In relation to the different presentations commonly seen after frontal lobe damage, Stuss and colleagues (2001) highlight damage to the left or right orbitofrontal areas consistently causes personality changes, impaired social judgement, diminished affective responsiveness and indifference, impaired pragmatics, problems with self-regulation, and inability to make use of feedback or previous experience. The anterior regions of the frontal lobes appear to be more important in drive, attention, motivation and inhibition of socially inappropriate behaviour (Robinson, 1998). Thus, damage to specific or localised areas of the frontal lobes should be associated with disrupted, but recognisable, patterns of behaviours, cognitive deficits or changes in emotional function (see Stuss & Levine, 2002). However, the exact nature of the frontal lobes is a matter of continued speculation due to the varied presentation and

pattern of impairments following lesions to this area of the cortex. It is often the case that some individuals present with quite pronounced deficits in cognitive functioning and/or changes in personality, whereas others show little obvious signs of impairment in day to day functioning (see Lezak et al., 2004).

Nonetheless, intact executive functioning is arguably critical to everyday life and enables individuals to initiate, monitor and terminate behaviour patterns (Phillips, 1997). Deficits in executive functioning have also been linked to psychosocial impairments, particularly in relation to the recognition of emotional expression (Borod et al. 1992; Zgalijardic et al., 2002), reduced empathy (Carota, Staub, & Bogousslavsky, 2002), and socially inappropriate behaviours (Hornak, Rolls, & Wade, 1996; Rolls, Hornack, Wade & McGrath, 1994). Impairments in all these areas may be observed in post-stroke patients (see Robinson, 1998), with the latter being the changes families often have the most difficulty in dealing with (Brooks & McKinlay, 1983). Executive impairments have also been found to be particularly important in determining rehabilitation and psychosocial outcomes (Crepeau & Scherzer, 1993; Villki, Ahola, Holst et al., 1994).

1.4 Social Functioning

In some ways social functioning is an all-encompassing term that comprises many different abilities or skills, which have all been studied extensively in different contexts and with different individual populations (Bach, Davies, Colvin et al., 1998; Baron-Cohen et al., 1985; Cicone, Wapner & Gardner, 1980; Cuerva, Sabe, Kuzis et al., 2001; Sullivan & Ruffman, 2004; Mengelberg & Siegert, 2003). Here it is used

to mean the competencies (or abilities) an individual must possess in order to interact appropriately with others in a range of social situations. Arguably, however, this still entails a significant and wide-ranging number of skills or abilities that have attracted a large amount of research and cannot be fully explored within the constraints of the present study. Therefore, the concept of social cognition will be outlined briefly before going on to discuss in more detail the ability to understand the thoughts and feelings of others. This latter concept is commonly referred to as Theory of Mind and is the main construct under investigation in the present study.

1.4.1 Social Cognition

The skills involved in social cognition include insight into one's own thoughts and behaviour. As previously outlined in section 1.2.5, a reduction of insight or self-awareness is a common consequence of brain injury, which can affect an individual's ability to evaluate and judge his or her actions. Good social judgement not only depends upon the capacity for awareness of self, it also relies on being able to have an awareness of others. These skills, in combination, allow an individual to accommodate feedback given by the social and physical environment and adjust his or her behaviour accordingly (Channon & Crawford, 2000). Wood (2001) points out that many of the social problems experienced by brain injured people occur because of these kinds of difficulties. He describes this more specifically as a form of social inattentiveness in that brain injured individuals do not appear to perceive relevant social cues.

An example of reduced awareness of self and others was demonstrated by a patient described by Prigitano (1991) who had undergone a surgical intervention to remove a right frontal tumour. Following this, the patient was reported by his spouse to have frequent difficulties in recognising when he had upset others. Another example of this kind of tactless social behaviour was described previously in the case of Phineus Gage. His case is also in keeping with findings from more recent studies of brain injured individuals, which indicate that orbitofrontal damage can result in relatively preserved cognition, but pronounced disturbance in social cognition of understanding subtle social and emotional cues (Cicerone & Tranerbaum, 1997).

According to Stuss and Levine (2002), the concept of self-awareness implies a metacognitive representation of one's own mental states, beliefs, attitudes and experiences. These authors also highlight that this self-reflecting ability is the basis for understanding the relationship of one's own thoughts and external events, and to understanding the mental states of others. The construct of empathy is also conceivably linked to the successful understanding of others and successful social functioning in the respect that it also requires the ability to differentiate between the self and others (Visser-Kaiser et al., 2002). This may account for why some brain injured individuals also display deficits in their ability to empathise with others. An investigation conducted by Grattan and Eslinger (1989) into alterations of empathy following stroke suggested this is a common problem with up to 56% of the patients in their sample generating empathy scores more than two standard deviations below the mean.

In a recent review conducted by Eslinger, Parkinson, & Shamey (2002), impairments in empathy were associated with lesions in either the left or right prefrontal cortex. In addition, they also reported that a lesion in the posterior cortical areas can result in reduced empathy, but only when localised to the right hemisphere. However, they concluded that impairments in understanding the mental states of others (i.e. Theory of Mind) may account for some of the empathic alterations demonstrated by right posterior stroke patients.

Another skill that has been linked to social cognition and, in turn, successful social functioning is the perception of emotions. This is primarily because assessing emotional and motivational states is critical to understanding the intentions of others, with faces, in particular, providing critical information about the emotional states of others (Norris, et al., 2004). Emotional processing (e.g. perception) is defined by Zgaljardic, Borod, and Sliwinski (2002) as the ability to perceive, express, and experience emotions across multiple channels of communication (e.g. facial, prosodic, and lexical/verbal). In a study conducted by Borod et al., (1998) right hemisphere damage was found to have a greater effect on emotional perception and expression than left hemisphere damage. However, in a recent review of emotional perception and expression following brain damage, Gainotti, Caltagirone and Zoccolotti (1993) suggest that right hemisphere damage is more likely to disrupt the autonomic components of an individual's emotional response than the ability to comprehend or express emotions. Damage to the right posterior cortices has been associated with the inaccurate perception of emotional facial expressions (Adolphs, Damasio, Tranel, & Damasio, 1996).

It has so far been described how deficits in self-awareness, reduced ability to empathise and impaired perception of emotions are common consequences of brain injury, particularly to the right hemisphere and frontal cortices. Although research has tended to focus on individuals with traumatic brain injury, more recent studies have investigated these social cognition deficits amongst stroke survivors who appear to display many of the same difficulties. It is also clear how these difficulties can lead to disrupted interpersonal relationships, decreased social contact and ultimately to a reduced quality of life. Social interaction difficulties have also been found to impede rehabilitation progress. Consequently, Carota et al., (2002) advocate the inclusion of social-related measures when assessing rehabilitation progress and overall outcome following stroke.

1.5 Theory of Mind

Another aspect of social cognition that is often viewed as inherent to successful social functioning is the concept of 'theory of mind'. The term theory of mind (ToM) was originally coined by Premack and Woodruff (1978) in an attempt to explain their findings that chimpanzees could successfully solve tasks that were dependent on realising another individual's intentions. In defining this ability, they proposed that an individual can be considered to possess a ToM if capable of imputing mental states to himself and others. Premack and Woodruff (1978) elaborated on this succinct definition by adding that a system of inference of this kind is properly viewed as a theory, firstly, because such states are not directly observable, and secondly, because the system can be used to make predictions about the behaviour of other organisms. Premack and Woodruff (1978) concluded that

there was evidence to suggest that the chimpanzees in their experiments possessed a ToM, and that this ability was therefore not particularly sophisticated in nature but essentially primitive.

This controversial idea of innateness is also supported by human studies of developmental disorders, in which deficits in ToM are thought to be implicated (Baron-Cohen, 1992; Leslie & Thaiss, 1992), and by functional imaging studies (Fletcher et al., 1995). However, Premack and Woodruff's (1978) pioneering study has been criticised in that its findings could just have easily been interpreted as displays of rule-based behaviour, which in turn, would not involve a ToM at all (Byrne, 1996). Since Premack and Woodruff's initial experiments, many researchers have been motivated to re-evaluate what constitutes ToM, and to further pursue an adequate explanation of its developmental course in humans. This has resulted in ToM abilities being explored extensively both with children (Mitchell, 1997; Wimmer & Perner, 1983) and adults (Bosacki & Astington, 1999; Baron-Cohen et al., 1997; Blair, Sellars, Strickland et al., 1996; Happe et al., 1998; Kinderman, Dunbar, & Bentall, 1998).

If one looks to the developmental literature, it appears that the emergence of ToM is graded, although the exact age at which a child is credited with possessing a ToM continues to be debated (De Gelder, 1987; Wimmer & Perner, 1983; Leslie, 1987; Chandler, Fritz & Hala, 1989), and seems to vary according to which form of ToM task is used. However, the dominant view is that during normal development ToM ability emerges around four years of age (Flavell, 1999). From a social perspective, there have also been some interesting studies conducted looking at the contribution

social experience makes to the understanding of others' mental states. In a study conducted by Happe et al. (1998) investigating the ToM abilities of younger and older adults, older adults were found to perform significantly better than younger adults on ToM tasks. Despite some deterioration being observed in other aspects of cognitive functioning in the elderly, these authors concluded that not only does ToM ability remain intact, but may even improve with age. However, other studies have failed to replicate these findings (Sullivan & Ruffman, 2004; Maylor, Moulson, Muncer & Taylor, 2002) although the idea of engaging in wide and varied social interactions (i.e. repeated practice) as an aid to social competence as a whole is supported by child studies (e.g. Perner, Ruffman & Leekham, 1994; Ruffman, Perner, Naito, Parkin, & Clements, 1998).

In an attempt to increase understanding of normal development of ToM, researchers have turned their attentions to cases where ToM ability appears to be lacking. For example, Baron-Cohen and colleagues (1985) argue that deficits in ToM can account for the psychosocial deficits regularly observed in autistic individuals. Autism is characterised by a distinctive triad of impairments in social, communicative and imaginative activities and, as a result, autistic individuals have a tendency to be self-involved and indifferent to others. In particular, they do not seem to take account of other people's feelings or intentions. Individuals with autism and Asperger's syndrome (AS) have consistently been shown to perform poorly on ToM tasks in the absence of impairments in general intelligence, which has led to the belief that ToM deficits are the primary cause. These findings, together with the social interaction

difficulties displayed by individuals with autism, also imply that an understanding of other people's minds is vital for social and emotional understanding.

1.5.1 Theory of Mind and the Brain

As outlined above, the ToM hypothesis postulates that there is a developmental deficit in ToM abilities in autism, but similarities have been noted between the behaviour of autistic children and adults who have suffered damage to the frontal lobes. This would suggest two things. Firstly, that the frontal lobes play a significant role in ToM and, secondly, that ToM ability can be 'knocked out' or impaired as a result of acquired brain injury. Indeed, patients with damage that includes both orbital and medial frontal cortex have been shown to have severe deficits in social functioning (Baron-Cohen, Ring, Moriarty et al., 1994; Damasio, Tranel, & Damasio, 1990). Several attempts have been made to delineate the brain regions involved in ToM and there is now growing evidence to further support both of these ideas in studies using normal and brain injured participants.

Neuroimaging studies have demonstrated activation in the frontal lobes (Fletcher et al., 1995; Baron-Cohen et al., 1994), as well as more posterior regions, such as the temporo-parietal junction, when neurologically intact adults perform ToM tasks (Saxe & Kanwisher, 2003). Although brain-imaging was not undertaken, findings from a study conducted by Apperly and colleagues investigating ToM ability in brain-injured patients also suggests prefrontal and temporo-parietal regions play a role in ToM ability (Apperly, Samson, Chiavarino & Humphreys, 2004). However, each used different kinds of ToM tasks, and it is therefore difficult to draw any firm conclusions from these studies. Additionally, in isolation, neuroimaging data do not

show whether particular regions are necessary for ToM reasoning, nor do they provide direct evidence about the functions of these areas in solving these tasks. Indeed, it has been argued that evidence from studies of brain-damaged individuals is vital to understanding Brain-ToM relationships (Bird, Castelli, Malik et al., 2004).

Shamay-Tsoory, Tomer, Berger et al. (2003) investigated empathic and theory of mind abilities in patients with ventromedial ($n = 12$) and dorsolateral ($n = 7$) frontal lobe damage. In the theory of mind component of this study, the authors included an assessment of 'faux pas'. Faux pas is believed to be a developmentally more sophisticated test of theory of mind and involves the representation of two mental states. The authors also argue that it incorporates both the cognitive and affective components of ToM (i.e. understanding that someone should not have said something and also that the person hearing it may feel upset or offended). Shamay-Tsoory et al. (2003) reported that patients with frontal lobe damage made significantly more errors than patients with posterior lesions or healthy controls. However, this study has been criticised by Bird et al. (2004) who highlight there were no significant difference in the number of errors made by the ventromedial lesioned group and the seven patients with dorsolateral frontal lobe lesions. In addition, detailed anatomical data regarding the critical lesions that impaired performance on the Faux Pas task were not reported. However, a detailed analysis of lesion sites associated with empathy deficits was performed, suggesting the right ventromedial frontal lobe as being particularly important in ability to empathise.

A study was conducted by Stuss, Gallup and Alexander (2001) in order to verify whether the frontal lobes are uniquely related to ToM, and if distinct regions, particularly in the right hemisphere, contribute to different processes related to ToM. In doing so, Stuss and colleagues investigated visual perspective taking and ability to detect deception in a sample ($n = 32$) of individuals with lesions in the right and left frontal and non-frontal areas of the brain. In the perspective-taking task, individuals had to infer the visual experience of others, whereas in the deception tasks, they had to be able to infer when somebody was trying to deceive. The findings of this study revealed that lesions throughout the frontal lobe were associated with impaired perspective-taking, with some suggestion of a more important role for the right frontal lobe. This fits with research that shows the right hemisphere as having a central role in the neural network for social cognition. However, the sample included individuals with different aetiologies (stroke, traumatic brain injury, lobectomy and tumour) and the number of each type of brain injury was not reported. Therefore, these findings only provide preliminary evidence for the role of the right frontal lobe in ToM ability.

Happe, Malhi, and Checkley (2001) reported on a case of a 76 year old man who had undergone surgical intervention targeting the neuronal connections between limbic thalamic nuclei and orbito-frontal cortex as a treatment for bipolar affective disorder. They investigated his ToM ability using story and cartoon materials requiring mental state attributions. Happe and colleagues reported that this gentleman was impaired on all ToM tasks, but performed within normal limits on control tasks. They

concluded disconnection of frontal and limbic regions can impair previously acquired ToM.

It has been outlined (see section 1.4) that successful social functioning is the outcome of a complex array of interacting cognitive, behavioural and affective competencies, although the ability to behave appropriately within a social context intuitively indicates an aptitude in understanding what other people may be thinking or feeling (e.g. theory of mind). Although not conclusive, the studies outlined above suggest several brain regions as being implicated in theory of mind, particularly the frontal lobes and the right hemisphere. Other studies have reported impairments in right hemisphere damaged patients on a range of other social reasoning tasks including comprehension of similes, metaphors, proverbs, sarcasm and humour (Brownwell, Simpson, Bihle, Potter, & Gardner, 1990). However, the brain injury studies that have so far been outlined used samples with mixed aetiologies and are therefore in no way conclusive. They are also hampered by the differing methodologies.

1.5.2 Theory of Mind and Stroke

As outlined in sections 1.5 and 1.5.1, theory of mind ability has been extensively studied in children, individuals with autism and neurologically healthy adults. More recently, the ToM concept has also been explored in schizophrenia (Mazza, De Riso, Surian et al., 2001) and degenerative neurological conditions, such as dementia (Cuerva, Sabe, Kuzis et al., 2001; Gregory, Lough, Stone et al., 2002; Lough, Gregory, & Hodges, 2001), and Parkinson's disease (Mengelberg & Siegert, 2003).

The ToM studies outlined in section 1.5.1 involved individuals with acquired brain injury, and most included individuals with varying aetiologies, such as traumatic brain injury and surgical intervention for tumour amongst others. However, there appears to be a paucity of studies that have investigated survivors of stroke (amongst other aetiologies) and, to the author's knowledge, only 3 studies to date have investigated the ToM ability specifically following stroke (Stone, Baron-Cohen & Knight, 1998; Happe, Brownell & Winner, 1999; Bird et al., 2004).

In the first of these studies, Stone et al., (1998) undertook to test a series of developmentally graded theory of mind tasks in frontal lobe patients to determine if any subtle ToM deficits could be detected. They tested patients with damage to the orbitofrontal cortex because they have been shown to have deficits in social behaviour. Participants included 5 patients (3 with aphasia) (age range 64-80) with unilateral lesions to the left dorsofrontal cortex (DFC) resulting from middle cerebral artery infarcts and 5 patients (age range 34-51) with bilateral damage to the orbitofrontal cortex (OFC) from traumatic brain trauma. They also included 5 non-brain-damaged controls matched for age and years of education. Three ToM tasks were used (first order and second order false belief, and faux pas) and working memory demands were controlled for. Stone and colleagues reported that the sample of stroke patients (DFC damage) were intact when detecting a faux pas in stories and had difficulty only on versions of the tasks that placed demands on working memory, whereas the traumatic brain-injured sample with more extensive bilateral lesions involving orbitofrontal cortex showed difficulties in detecting faux pas. Both groups were able to perform first and second-order false belief tasks, providing the memory demands of these were low. They concluded that the OFC is

part of a ToM circuit involved in ToM tasks with an affective component (*faux pas*), and that the DFC cortex is not crucial to the ToM circuit. However, this study did not investigate the anterior/posterior dimension, non-frontal lesions were not included, nor did it include patients with unilateral right frontal damage. It is also likely that diffuse axonal damage was present in the traumatic brain-injured group. This type of injury is common amongst brain trauma patients and is often not apparent on brain scans.

Happe, Brownwell and Winner (1999) used the 'strange stories' paradigm developed by Happe (1994) to investigate acquired deficits in ToM in individuals who had sustained lesions to the right hemisphere following stroke. Individuals with right hemisphere damage are known to show pragmatic and social difficulties. Participants included 14 individuals with right hemisphere damage (RHD) (5 males, 9 females) with an age range from 51 to 75 (mean age 64 years). Eight participants in this group were between 7 and 23 years (mean 10 years) post stroke. The additional six participants in the RHD group had suffered more recent strokes and were between 4 and 9 months (mean 5 months) post stroke. Five participants (4 males, 1 female) who had suffered left hemisphere lesions were also included. The age range for this group was between 54 and 80 (mean age 67 years) and the range of time since stroke was 12 months to 21 years (mean 9 years). All the patients in the LHD group were aphasic. The control group comprised of 19 healthy individuals (9 males, 10 females) aged between 61 and 80 (mean age 73).

Happe et al's (1999) study included two parts. In the first, the task used involved 16 short stories of two types (ToM stories and non-mental state stories). The ToM

stories concerned double bluff, mistakes, persuasion and white lies. Following each story, participants were required to make inferences about the characters' thoughts and feelings and also to make an inference about the intentions of the protagonist in the story. Control stories also involved people, but inferences concerned physical aspects of the story. In the second part of the study 12 humorous cartoons were used (6 ToM and 6 non-mental state cartoons). In the ToM condition, the humour in the cartoons was dependent upon what a character mistakenly thought (false belief) or did not know (ignorance). The non-mental cartoons involved a physical anomaly or a violation of a social norm.

The performance of RHD patients on each of these tasks was compared to the performance of LHD patients and controls. The RHD patients' understanding of materials requiring attribution of mental states was reported as being significantly worse than their understanding of non-mental control materials. They were also found to be significantly more impaired on both theory of mind tasks when compared to LHD patients and controls. These authors also argued that this deficit was shown not to be a function of task difficulty.

These findings were perhaps not unexpected given the large amount of evidence implicating right hemisphere damage in impairments of social awareness and behaviour. However, the anterior-posterior dimension was not explored in this study, therefore it is difficult to conclude whether anterior or posterior regions of the brain played a role in performance on ToM tasks. The story tasks were modified for the LHD group due to aphasia with a forced-choice answer format being used. Thus, it could be argued that this modification reduced the difficulty and comparability of

the task (see Channon & Crawford, 2000). Further criticisms of this study include the fact that premorbid ability was not fully explored and there was a considerable range in time since stroke (e.g. from 12 months to 21 years). Therefore, although individuals with right sided lesions were shown to demonstrate impaired ToM functioning following stroke, conclusions should be viewed tentatively. Further investigation would be required in order to clarify whether the source of the deficit was indeed located in the right hemisphere, or whether there is some other account. For example, as previously outlined in section 1.5.1, children and adults with Asperger's syndrome perform poorly on these types of tests (Baron-Cohen et al, 1997), and activation of the medial frontal cortex has been demonstrated in imaging experiments when ToM stories have been used with healthy individuals (Fletcher et al., 1995).

The previous two studies involved groups of patients; however, the impact of stroke on ToM ability has also been described in a single case study (Bird et al., 2004). Bird and colleagues reported on a 62 year old female who suffered an exceptionally rare form of stroke – bilateral anterior cerebral artery infarction. Neuroimaging investigations revealed extensive damage to the medial frontal lobes bilaterally, including regions identified to be critical for ToM by functional neuroimaging of healthy participants. These investigators carried out a range of tests including tests of language, perception, memory, executive function, intellectual functioning, and a battery of ToM and social cognition tests. The patient was reported as showing evidence of a dysexecutive syndrome characterised by impairments in planning and prospective memory. She also had a tendency to confabulate. However, Bird et al. (2004) also reported that the patient did not demonstrate any significant impairment

on tasks assessing her ability to construct a ToM when compared to the performances of 12 age and IQ matched controls. These included a picture sequencing task that requires understanding of the characters' mental states, Happe's (1994) ToM task, as outlined above, and a test of faux pas. These authors concluded that the patient's performance is suggestive of no difficulty in understanding complex social interactions requiring the representation of mental states, and that the extensive medial frontal regions destroyed by her stroke are not necessary for this function. However, the patient was reported as demonstrating a mild insensitivity to embarrassing situations and a slight blunting of empathy for other people. Therefore, Bird et al conceded that a more tentative conclusion would be that these findings suggest that regions of the medial frontal lobes damaged in this patient are not necessary for at least the cognitive aspects of ToM.

1.5.3 Theory of Mind and Executive Function

Throughout the literature there have been frequent claims that theory of mind (ToM) is mediated by general executive functioning and, consequently, that poor performance on ToM type tasks should not necessarily be interpreted as indicative of poor ability in this area of social cognition (Carlson, Moses & Breton, 2002). As outlined in section 1.3, executive functioning is believed not to be responsible for basic cognitive processes but for the set of behavioural competencies that integrate these capacities. Therefore, it is possible that impairments in executive functions such as self-awareness and monitoring of behaviour, response inhibition, planning and decision-making may interfere with both social and non-social functioning.

Evidence comes from a number of sources to support the suggestion that executive functions mediate ToM performance, but are not conclusive.

Firstly, recent studies have found that ToM and executive function abilities are correlated in pre-school children (Frye et al, 1995) and additionally, that executive function performance predicts ToM performance, but not vice versa (Frye et al., 1995). The tests often used with children have also been extensively criticised and have been suggested as measuring something other than ToM, such as working memory capacity (Davis & Pratt, 1995), or executive function (Zaitchik, 1990; Hughes & Russell, 1993). Indeed, in a recent study by Carlson and colleagues (2002), varying executive function demands in ToM tasks was found to increase or decrease performance in predictable ways. These authors also suggested that a combination of inhibition and working memory may be fundamental to the relationship between executive function and ToM.

There is also debate in the autism literature about the specific relationship between ToM and executive functions, and the extent to which these constructs represent separable independent processes. Executive dysfunction has also been reported in studies of autistic individuals, in addition to poor performance on ToM tasks (Rumsey & Hamburger, 1988; Leslie and Thais, 1992). Similarly, a study conducted by Ozonoff and colleagues (1991) found a correlation between performance on executive function and ToM tasks in individuals with autism, but not in healthy control participants. Thus, it has been suggested that the difficulty autistic individuals have on ToM tests is at least partly attributable to their lack of executive control. Similarly, in a recent review of the literature, Perner and Lang (2000)

highlighted that the association between ToM and executive function performance is found even when theory of mind explanation tasks that have a low executive function component are used.

Fine et al., (2001) highlight that most tests used to assess aspects of cognitive function are not pure; they inherently assess other aspects of functioning. It stands to reason then that ToM tasks may not be pure ToM tasks, but may also involve an executive function component amongst others. Therefore, it could be asserted that correlations between performance on tests of executive function and ToM tasks should be expected. However, another explanation for the associations found may be that regions of the brain that mediate ToM and executive functions are anatomically close to each other (Fine et al., 2001).

Theory of mind deficits may be correlated with executive functioning due to the involvement of the frontal lobes. Comparisons of anterior-posterior damage have argued for a specific role of the frontal lobes in executive functions (Reitan & Wolfson, 1994) and both sets of skills appear to be subserved by a common brain region (the PFC) in adults (Fletcher et al., 1995; Goel et al., 1995; Stuss & Levine, 2002). Previous research by Bach, Davies and Colvin et al. (1998) of a single case with bilateral frontal damage also suggested that prefrontal damage may be associated with ToM and executive impairment.

This hypothesis was investigated by Channon and Crawford (2000) in a study investigating participants with unilateral anterior and posterior lesions. Both these

brain-injured groups were compared to a healthy group of individuals on a theory of mind-type task that involved explaining the words and actions of story characters in a series of brief vignettes. Participants also carried out a set of non-social neuropsychological tests to permit examination of the relationship between executive dysfunction and performance on a theory of mind-type task. The results showed that those with left anterior brain lesions ($n = 6$, mean age, 40.83) showed impairment relative to those with right anterior ($n=13$, mean age, 44.85), left ($n=4$, mean age, 48.25) and right posterior lesions ($n=8$, mean age, 43.00) and healthy participants ($n=60$, mean age, 43.13) in story comprehension. The other lesion groups did not differ significantly from the healthy group on any story comprehension measures. The left anterior lesion participants also showed impairment on some measures of executive function, but not all.

These authors concluded that in their study, impaired executive function provided a sufficient explanation of impaired story comprehension performance, without needing to invoke the concept of an additional theory of mind impairment. However, because of the need for adequate language processing to complete the tasks, there were more right-sided than left-sided lesion patients in the study. Patients were excluded if they had expressive or receptive aphasia. The nature of some of the errors made by the left anterior group, such as merely repeating some of the information already given in the story outlined to them, raises the possibility that these participants perhaps did not understand what was required of them. It is also possible, given lesions were in the left frontal region of the brain, that this group of individuals had undetected language impairment. An alternative explanation that Channon and Crawford (2002) highlight is the possibility of impairments in both

domains arising from damage to critical brain areas affecting both sets of processes. It seems reasonable therefore to hypothesise that damage to the frontal lobes can result in a reduced ability to understand the mental states of others. The consequence of this would be poor social functioning.

Despite the above evidence that suggests ToM deficits can be understood as impairments in executive function, there is also evidence that suggests these abilities are independent. Rowe, Bullock, Polkey, and Morris (2001) investigated the relationship between ToM ability and executive functioning in 31 patients with unilateral lesions of the frontal lobes (prefrontal lesions) (15 right-sided and 16 left-sided) and 31 healthy controls using first and second order false belief tests. Their findings showed that patients with left frontal and right frontal lesions were equally and significantly more impaired on ToM tasks than controls. Both frontal lobe groups also exhibited a range of deficits on tests of executive functions, which the authors reported as being independent of ToM. However, almost half of the patients had received surgical treatment for intractable epilepsy, and it is widely accepted that longstanding epilepsy may be associated with atypical cerebral organisation of cognitive functions. Therefore it is difficult to draw any firm conclusions about the true nature of ToM and executive function from these findings. However, independence of ToM ability from executive function is supported by other studies.

Bach, Happe, Fleminger and Powell (2000) investigated ToM ability (stories and cartoons), its relation to executive functioning, and the role of the frontal cortex in a 59 year old adult male with extensive damage to the orbitofrontal cortex and

disturbance in social behaviour resulting from closed head injury. This patient completed assessments on admission, and at 6 and 12 month follow-up. He was found to perform as well as elderly control participants (mean age 73) on Happe et al.'s (1994) strange story task, but displayed some difficulty with understanding humour in the tasks involving cartoons. This patient was also reported as having significant difficulties on tasks of executive function, particularly in relation to self-monitoring, response to feedback, and with initiating tasks. He did not, however, show a global impairment in executive functioning, displaying an ability to problem solve within a concrete context and demonstrated flexibility of thinking. Bach and colleagues (2000) concluded their findings suggest that executive ability is not a necessary component of the cognitive processes underlying ToM ability. However, the authors conceded that their ToM task may not have been significantly complex enough to necessitate orbitofrontal involvement. There are also difficulties in comparing this gentleman's performance to that of a group of adults who were considerably older.

It is difficult to generalise the findings from a single case study to the wider brain injured population especially when the opposite pattern of dissociation has also been reported. For example, Happe, Malhi & Checkley (2001) studied a patient with frontal lobe damage following surgical intervention. This patient was found to be severely impaired in his ability to represent mental states, but showed no indication of executive function impairment. Happe et al. (2001) therefore concluded that failures on ToM tasks are not simply a function of executive dysfunction. There have also been recent suggestions that the amygdala may be involved in the

development of the circuitry mediating ToM (Fine et al., 2001). As outlined previously, the amygdala has interconnections with regions of the prefrontal cortex, and both these areas have been implicated in the circuitry that mediates ToM (Fletcher et al., 1995; Goel, et al., 1995).

As alluded to above, studies with both children and adults have produced conflicting results about the lateralisation of ToM function (e.g. Channon & Crawford, 2000; Happe, Brownell & Winner, 1999; Stone, Baron-Cohen, & Knight, 1998) and/or whether the frontal lobes (or executive functions) are necessary (e.g. Bird, Castelli, Malik, Frith & Husain, 2004; Fine, Lumsden, & Blair, 2001). It seems possible that this pattern of findings is the result of difficulty in finding appropriate tasks for testing ToM and more likely due to the fact that different studies have used different types of ToM tasks. There are also difficulties in relation to the executive tasks used in these studies. Executive function refers to a wide range of abilities (see section 1.3) and different aspects of executive function have been shown to be dissociable (Burgess & Shallice, 1997). Individuals may perform well on one type of executive function task and not on another. Therefore, which aspect of executive function is being tapped is dependent on the type of measure used. Nonetheless, it seems that some aspect of executive function is necessary (if not sufficient) for successful performance on ToM tasks.

1.6 Summary

Incidence rates suggest stroke as being relatively common amongst the general population and the Scottish Intercollegiate Guidelines Network (2002) report stroke as being the most frequent cause of severe disability in the United Kingdom.

The consequences and rate of recovery from stroke can vary significantly among individuals depending on the location and extent of lesion amongst other factors. However, in addition to motor dysfunction, changes in affect and cognitive and emotional deficits are frequently associated with stroke and have been shown to impact on recovery rates and rehabilitation outcomes. In particular, cognitive and emotional impairments constitute one of the major obstacles to recovery and to achieving maximal quality of life following stroke. They can also disrupt processes central to social interaction and, in turn, can affect psychosocial functioning. (Hochstenbach, Mulder, van Limbeek et al. , 1998; Rasquin, Verhey, Lousberg et al., 2002; Stephens, Kenny, Rowan et al., 2004; Elinger, Parkinson & Shamay, 2002; Bogousslavsky, 2003; Eslinger et al., 2002).

Within the realm of social cognition, brain injury research has increasingly focussed on a specific element of social competence: the ability to attribute mental states (e.g thoughts, feelings, desires, and beliefs) in order to explain and predict people's behaviour. This ability is termed Theory of Mind (ToM) (Baron-Cohen et al, 1985), and normally develops in the pre-school years. It has been suggested that the development of ToM rests on an innately predisposed, cognitive mechanism, or more conservatively, a neural network (Baron-Cohen et al., 2001). This controversial idea of innateness is supported by human studies of developmental disorders, in which

deficits in ToM are thought to be implicated (Baron-Cohen, 1992; Leslie & Thaiss, 1992), and by functional imaging studies (Fletcher et al., 1995). It follows then, in theory, that this mechanism or neural network could be damaged following acquired brain damage in adulthood, resulting in acquired impairments in ToM.

It has been argued that the frontal lobes are necessary for ToM (Shamay-Tsoory, Tomer, Berger et al., 2003; Stuss et al., 2001), and that the frontal cortex mediates executive functioning (Dela Salla et al., 1998). Therefore, it seems reasonable to predict that if an individual has deficits in ToM they might also show deficits in executive functioning. However, these abilities have been shown to be dissociable from one another in adults with frontal lobe lesions (Rowe et al., 2001; Bach et al., 2000; Happe et al., 2001) and studies with both children and adults have produced conflicting results about the lateralisation of ToM function (e.g. Channon & Crawford, 2000; Happe, et al., 1999; Stone et al., 1998) and/or whether the frontal lobes (or executive functions) are necessary (e.g. Bird et al., 2004; Fine et al., 2001).

Regions of the frontal cortex have been shown to have multiple reciprocal connections with subcortical structures and individuals with damage to these areas have also been found to display difficulties similar to those seen in individuals with specific frontal lobe lesions and to have deficits in ToM (Happe et al., 2001). Additionally, there is a large amount of evidence implicating right hemisphere damage in impairments of social awareness and behaviour (Stuss et al., 2001, Happe et al., 1999). Therefore, it seems reasonable to conclude that many regions of the brain may be involved in ToM ability, with the frontal lobes and right hemisphere perhaps having particular importance. In relation to the executive function/ToM

debate, the literature appears to suggest that some aspects of executive function are necessary, yet not sufficient, for successful performance on ToM tasks. In other words, executive functioning deficits are not solely responsible for poor performance on ToM tasks and that these abilities are in some ways mutually exclusive.

1.7 Present Study – Aims and Hypotheses

To date, only one published group study has looked at acquired ToM deficits following right hemisphere stroke (Happe et al, 1999). These authors found that patients who had suffered a right hemisphere stroke, a group known to show pragmatic and social difficulties, performed significantly worse on ToM tasks compared to left hemisphere damaged patients and healthy controls. However, Happe and colleagues (1999) did not investigate whether executive functioning deficits could have been a contributory factor to these findings, nor did they investigate the anterior/posterior dimension of brain lesion localisation. (see section 1.4.2 for additional criticisms of this study).

1.7.1 Aims

In view of the above, the main aim of this study was to extend the work carried out by Happe and colleagues by further investigating a component of everyday social understanding commonly referred to as Theory of Mind (ToM) in post-stroke individuals. A different ToM measure was used in this study for various reasons (see section 2.3.2), but primarily to allow for the inclusion of individuals with expressive dysphasia. In addition to the right/left hemisphere division, the anterior/posterior dimension of brain lesion localisation was also investigated. The second aim was to

investigate the performance of stroke patients on measures of executive function compared to controls and, finally, the third aim of this study was to investigate the relationship between ToM ability and executive functioning in post-stroke individuals.

This research was considered to be of value because impaired ability to attribute mental states to others has implications for the individual, progress in therapy (i.e. rehabilitation), and relevance for relatives, carers and allied professionals.

1.7.2 Hypotheses

Theory of Mind (ToM)

It was hypothesised that:

- (i) Individuals with right-sided lesions will perform significantly worse on the ToM task than either individuals with left-sided lesions or healthy controls.
- (ii) Individuals with anterior lesions will perform significantly worse on the ToM task than either individuals with posterior lesions or healthy controls.
- (iii) There will be no significant difference in performance on the ToM Control Task between stroke patient groups and controls.

Additional research question: Although no specific predictions were made, it was also planned to investigate whether any specific lesion site (e.g. right anterior or right posterior) is more detrimental to ToM ability than other lesion locations (e.g. left anterior or left posterior).

Executive Function

It was hypothesised that:

- (iv) Both stroke groups (right- and left-sided lesions) will be significantly impaired on measures of executive function compared to controls.
- (v) Individuals with anterior lesions will be more impaired on measures of executive function compared to individuals with posterior lesions and controls.
- (vi) Patients with right-sided lesions will show less awareness of executive function deficits compared to patients with left-sided lesions.
- (vii) Patients with anterior lesions will show less awareness of executive function deficits compared to patients with posterior lesions.

Theory of Mind and Executive Function

It was hypothesised that:

- (viii) Amongst stroke patients there will be a significant positive relationship between measures of executive function and ToM.

However,

- (ix) Executive function deficits will not fully account for impairments in ToM ability amongst stroke patients.

CHAPTER TWO: METHOD

2.0 METHOD

2.1 Design

This study was of mixed factorial design and involved both within and between subjects comparisons. The independent variable was group (stroke and control). The dependent variables were the participants' scores on each of the measures used in this study, and stroke participants' scores were compared to normative data and to a control group during analysis. Each participant was seen individually on one occasion, during which all parts of the assessment battery were administered.

2.2 Participants

During the inclusion period, both rehabilitation wards were always at full capacity (38 beds) in terms of bed occupancy and 26 stroke patients were admitted to both rehabilitation wards. Of these, 34 were eligible to take part in the study. All but two participants approached agreed to take part.

In total, 70 participants took part in this study. The experimental group comprised of 30 individuals (left-sided lesion $n = 15$, right-sided lesion $n = 15$) who had received a diagnosis of stroke and were in-patients of two Stroke Rehabilitation wards at Woodend Hospital, Aberdeen. Control group participants ($n = 40$) were recruited via a local community group (local church). Each participant was asked for their voluntary co-operation and no incentive was offered for participation.



2.2.1 Inclusion Criteria

To be involved in the study, stroke participants had to meet the following criteria:

- Diagnosis of stroke (within the past 6 months)
- Adults over the age of 18

In addition, only those individuals deemed medically stable by the Consultant Physician were considered for inclusion in the study.

2.2.2 Exclusion Criteria

Participants were excluded from the study if they met any of the following criteria:

- English was not their first language
- incapable of informed consent
- had a previous or current medical history which is known to affect cognitive functioning (i.e dementia, significant brain/head injury, substance/alcohol abuse)
- previous or current history of psychosis
- currently aphasic or suffering from receptive dysphasia
- had visual or hearing impairments that would hinder performance of tasks

2.2.3 Demographic Information

The following information was recorded for both stroke and control participants:

- sex
- age
- years of formal education

2.2.4 Stroke Information

The following information was also gathered retrospectively (after consent had been given by the participant) from the stroke participants' medical notes:

- type of stroke (Oxford classification, Bamford & Sandercock, 1991)
- location of lesion
- length of time since stroke

2.3 Measures

A total of seven separate measures were used in this study. In addition to an estimate of pre-morbid functioning, the tests used in this study were believed to measure 'theory of mind' ability, executive functioning, and mood.

2.3.1 National Adult Reading Test (NART)

Vocabulary is believed to correlate with overall intellectual ability and residual vocabulary is felt to be the best indicator of pre-morbid mental ability (Lezak, Howieson & Loring, 2004). With this in mind, The National Adult Reading Test (NART-2) (Nelson & Willison, 1991) was specifically designed to provide a means of estimating the pre-morbid intelligence levels of adult patients suspected of suffering from intellectual deterioration, and to provide a sensitive measure of previous familiarity with words, rather than a measure of continuing ability to analyse a complex visual stimulus (Nelson & Willison, 1991). The NART (Nelson & Willison, 1991) was therefore used in this study as a measure of pre-morbid intelligence in the stroke participants, and to ensure that individuals in the control group fell at least within the average range for intelligence.

The NART (Appendix 1) comprises a list of 50 words printed in order of increasing difficulty, and they are all 'irregular' or 'atypical' with respect to the common rules of pronunciation. Therefore, applying the common grapheme-phoneme and stress rules of the English language would result in incorrect pronunciation, and it has been argued the words can only be read and pronounced correctly if the subject is familiar with their written form (Nelson & Willison, 1991).

The NART requires subjects to read the list aloud, and the number of errors made is recorded. From this reading error score, Revised Wechsler Adult Intelligence Scale, (WAIS-R) verbal, performance, and full-scale IQs can be predicted. A factor analytic study combining the NART and WAIS-R found the NART error score to have a high loading on what was identified as verbal intelligence (Crawford, Stewart, Cochrane, Parker, & Besson, 1989). Crawford and colleagues (1989) conducted further analyses on the NART and found significant correlations with education ($r = .51$), test-retest reliability ($r = .98$), and inter-rater reliability between .96 and .98. A significant correlation between NART IQ score and age has also been found ($r = -.18$), although accounted for practically none of the variance (Crawford, Stewart, Garthwaite, et al., 1988). In a recent study of 55 survivors of traumatic brain injury, performance on the NART was reported as being affected by brain injury severity and thus may underestimate true premorbid ability (Morris, Lyndsay, Dunn & Teasdale, 2005). This is an interesting finding because such measures have previously been viewed as being resistant to most neurological disorders. These findings were published after data collection for this study had been completed.

2.3.2 Reading the Mind in the Eyes Test (revised version)

The 'Reading the Mind in the Eyes' test (Baron-Cohen, Wheelwright, Hill, Raste & Plumb, 2001), or 'Eyes Test' as it is more commonly known, was developed as an adult measure of Theory of Mind (ToM) ability for use with individuals with Asperger's syndrome (AS). The version used in this study is a revised version of the original Eyes Test (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997), with modifications made by Baron-Cohen and colleagues (2001) to render it a more sensitive measure of adult social intelligence (i.e. increasing the number of mental state choices from 2 to 4). This revised version consists of 37 pictures of black and white photographs of the eye region of the face (1 practice and 36 test items), which portray a particular expression or emotion. Participants are required to choose a word, from a possible four, which they believe best describes what the person in the picture is thinking or feeling (Appendix 2). Examples of the mental state terms are words such as fantasising, worried, reflective, preoccupied, amused, etc. It is argued that successful completion of this task is dependent on an adequate conception of another's mental states, and an ability to attribute mental states and emotions to others (Baron-Cohen et al., 1997). Because of this, The Eyes Test is argued to represent the affective component of ToM because it involves basic aspects of emotion recognition. However, Baron-Cohen and colleagues (2001) do point out that the Eyes Test only involves the first stage of attribution of theory of mind. Participants only have to identify what the person in the picture is thinking or feeling (e.g. compassion), as opposed to the second stage: inferring the content of that mental state (e.g. compassion for her mother's loss). However, they argue that

attribution of the type of mental state is part of theory of mind, even if it is not all of it (Baron-Cohen, Wheelwright, Hill, et al., 2001).

Normative data for the revised Eyes Test was obtained from a study using this task to examine ToM abilities in a group of individuals with a diagnosis of AS ($n = 15$) and among a control group of 'normal' adults ($n = 239$). Validation analyses revealed the Eyes Test as successful at differentiating between controls and individuals with AS based on total scores obtained. These authors also found no significant correlation between the Eyes Test and IQ ($r = .09$, $p = .6$), suggesting that ToM ability is independent of general (non social) intelligence. However, in a recent study carried out by Phillips (in preparation), some items of the revised Eyes Test were found to be unreliable. Therefore, Phillips (in preparation) removed those items which people were scoring 100 per cent or close to chance on, resulting in a shortened version comprising 26 items (1 practice, and 25 test items).

There are a number of tests used to assess ToM ability, however many of these were designed for use with children (e.g. Wimmer & Perner, 1983; Zaitchick, 1990) and therefore unsuitable for use in this study. There are also other ToM measures developed specifically for use with adults (e.g. Kinderman, Dunbar, & Bentall, 1998; Happe, Winner, & Brownell, 1998), but after consideration, the modified version of the Eyes Test described by Phillips (in preparation) was used in this study. As highlighted above, the Eyes Test was designed to be used with adults with AS. However, Baron-Cohen et al. (2001) highlight its relevance for clinical groups beyond those on the autistic spectrum (e.g. acquired brain injury). Consideration

was also given to the patient group under investigation, and the researcher chose the Eyes Test because it has less cognitive load, less of a verbal component, and can therefore be used with patients suffering from expressive dysphasia. Patients can point to their chosen response. Another reason for choosing this version of the Eyes Test was the reduced administration time. Fatigue is a common consequence of stroke, and therefore keeping testing time to a minimum was seen as preferable.

2.3.3 Eyes Control Task

Some adult ToM tasks (Kinderman et al, 1998) include a task designed to control for the possibility of other factors affecting performance, such as memory, and to be more confident that the psychological construct under investigation is indeed being measured. Using the same photographs used in the Eyes Test, Baron-Cohen and colleagues (2001) developed a separate control task for the Eyes Test in which subjects are asked to judge the sex of the person. Developing this further, Phillips (in preparation) modified the Eyes Test control task (Appendix 3). Participants are still required to identify the sex of the person, but in addition, are also asked to identify the age of the person, from a choice of possible four age range answers. If participants are performing poorly on this control task, it would call into question whether they had indeed understood what was required of them in the Eyes Test, or the possibility that they had visual problems affecting performance. The version developed by Phillips (in preparation) was used in this study, primarily because it corresponded with the version of the Eyes Test also used in this study.

2.3.4 Verbal Fluency (FAS)

Measures of verbal fluency are widely used in neuropsychological assessment, and have been shown to be especially sensitive to disorders involving the frontal lobes (Janowsky, Shimamura, Krichevsky, & Squire, 1989; Henry & Crawford, 2004). The most common verbal fluency task consists of four word-naming trials; three letters, and one category (Appendix 4). The letter fluency stimuli used in this study were the letters 'F', 'A', and 'S', and the category fluency cue was 'animals'. In line with administration instructions, participants were required to say as many words as they could think of beginning with the given letter of the alphabet, excluding proper nouns, numbers, and the same word with a different suffix. The letter fluency score, which is the sum of all acceptable words produced in three one minute trials (i.e., one minute for each letter), was then adjusted for age, sex, and education (Gladsjo, Miller, & Heaton, 1999). Similarly, in the category fluency trial, participants were asked to generate as many animals as they could think of, beginning with any letter of the alphabet. One minute was allowed for this trial. The category fluency raw score was the total number of animals given, which was also then adjusted for age, sex and education (Gladsjo et al., 1999).

The normative data used in this study was based on a review of the larger normative studies (with at least 100 participants) for oral FAS and animal fluency tasks (Gladsjo et al., 1999). The normative sample, used in the development and validation of the normative data, consisted of 768 adult volunteers who were enrolled as normal comparison participants in ongoing research studies of various neurological and psychiatric disorders at the University of California. Participants

ranged in age from 20 to 101 years ($M = 50.4$ years, $SD = 19.4$). The influence of demographic variables on letter and category fluency performance was examined in a sample of 403 individuals. Multiple regression analyses revealed that education, age and ethnicity accounted for a significant proportion of the variance in both types of verbal fluency performance. Results of correlational analyses and ANOVAs demonstrated that the T-score conversions removed all or most demographic biases from the sample (Gladsjo et al., 1999).

Reduced verbal fluency is argued to reflect impaired mental flexibility and difficulty shifting set (between letters), which are considered to be important aspects of executive functioning (Mitrushina, Boon, & D'Elia, 1999; Baldo & Simamura, 1998). Henry and Crawford (2004) carried out a meta-analysis of 31 studies ($n = 1791$) investigating the sensitivity of verbal fluency to the presence of focal cortical lesions. They concluded that their findings provided strong support for the validity of both letter (phonemic) and category (semantic) fluency as executive measures and indicated that letter fluency is more sensitive to frontal dysfunction than the Wisconsin Card Sorting Test (WCST) (Heaton, 1993). This task was therefore included in the assessment battery because executive functioning is one of the constructs under investigation. Its relatively quick administration was also a consideration, attempting to keep testing time to a minimum.

2.3.5 The Brixton Test

The Brixton test (Burgess & Shallice, 1997) (Appendix 5) is a rule detection and rule following task designed to assess executive function. In addition to assessing

the ability to detect and follow a rule, the task also assesses response flexibility to the changing patterns. This type of test, of which the WCST (Heaton, 1993) is probably the most well-known example, is known to present problems for patients with frontal lobe lesions, and failures on such tests are arguably the most commonly reported dysexecutive sign seen in formal examination (Burgess & Shallice, 1997). It consists of a 56 page stimulus book: each page showing the same basic array of ten circles set in two rows of five, with each circle numbered from one to ten. On each page, one of the circles is filled in with a colour (blue). The position of this filled circle differs (on most presentations) from page to page. The subject is shown one page at a time and is asked to consider where the next filled position will be by trying to identify a pattern, or 'rule', based on what they have seen on previous pages. There are nine rules in total based on the positions of the coloured circle on preceding cards. For the simplest rule, the coloured circle advances one position clockwise on successive cards; a later rule has the circle alternating from position 5 to 10. Differing from the WCST, subjects are not verbally informed whether their choice is correct or incorrect. The measure used to calculate scaled scores is the total number of errors made.

Burgess and Shallice (1996) have shown that there is no one reason for failure on this task. They identified three broad classes of error: perseveration (i.e. repeating one's response); the misapplication of a strategy; or guessing or bizarre responses. Burgess and Shallice found that people with frontal lobe lesions were generally poorer at the Brixton test than controls and posteriorly-lesioned patients, and also tended to make significantly more of the last category of error – bizarre or guessing behaviour.

Standardisation of the Brixton task was based on the performance of 121 controls (age range 18-80), and 77 patients categorised according to lesion location. The patient group consisted mainly of individuals with tumours, although the sample did include 13 individuals suffering from vascular lesions (infarct and haemorrhage). The split-half reliability of the Brixton Test for the entire control group ($n=121$) was found to be quite adequate 0.62 ($p<0.001$). The overall test re-test reliability for all subjects was 0.71 ($p<0.001$), which the test authors argue compares well with that obtained for a well-established test of general intelligence (Raven's Advanced Progressive Matrices, set 1, (Raven, 1943). Age and NART IQ were found to be related to performance, however, there were no significant sex effects (Burgess & Shallice, 1997). The Brixton Test has also been found to have modest ecological validity (i.e., it is predictive of everyday behaviour) (Odhuba, van de Broek & Jones, 2005).

Burgess and Shallice (1997) describe the Brixton as a straightforward test, and one which is more pleasant (and quicker) for the participant to perform than some others, and which is quick to score and interpret. The test authors also argue that the Brixton test is better than most other concept attainment tasks because it provides good data distributions in normal subjects, avoiding range restrictions, and therefore making test interpretation less problematic. In addition, subjects are able to do this task non-verbally, thus allowing for the inclusion of individuals with expressive dysphasia. These were the main considerations for including it in the assessment battery used in this study.

2.3.6 Dysexecutive Questionnaire (DEX): Behavioural Assessment of the Dysexecutive Syndrome (BADS)

The Dysexecutive Questionnaire (DEX) is part of the Behavioural Assessment of the Dysexecutive Syndrome (BADS) test battery (Wilson, Alderman, Burgess, Emslie, & Evans, 1996), but can be used independently of the other tests. The DEX is a 20 item symptom checklist designed to measure a range of difficulties commonly believed to be involved in executive dysfunction, such as abstract thinking problems, lack of insight and social awareness, distractibility, loss of decision-making ability and so on. The questionnaire samples four broad areas of likely changes, such as, emotional and personality changes, motivational changes, behavioural changes, and cognitive changes, and includes statements such as “I act without thinking, doing the first thing that comes to mind,” and “I find it difficult to keep my mind on something and am easily distracted”. Each item is scored on a 5-point (0-4) Likert scale (ranging from ‘never’ to ‘very often’) and an overall impairment score (maximum 80) is derived from totalling the 20 individual item scores.

There are two forms of the DEX. One is designed to be given to the patient (Appendix 6) and the other (Appendix 7) to someone who knows the subject well, which in this study was either the named nurse for the patient, or a member of therapy staff who worked with the patient regularly. The questions on each are identical, except for minor changes in phrasing. On occasion during this study, the DEX was read aloud to the patient, and each item was gone through individually, allowing adequate time for the individual to consider each question. The higher one scores, the poorer executive functioning is thought to be. Additionally, by

comparing the two (self and independent rater), one can compute a difference score to judge level of insight. The manual reports a significant difference in how patients rate themselves, and how others rate them; patients, as a group, rate themselves as having less problems than their significant others are reporting. This is argued to reflect problems of reduced insight, which is a known and common difficulty reported in the brain injury literature. The manual reports a significant correlation ($-0.62, p < 0.01$) between the overall BADS profile score of dysexecutive difficulties for the patient sample ($n = 92$), and the others' ratings of these individuals on the DEX questionnaire of executive functioning.

2.3.7 Beck Depression Inventory (BDI-II)

The revised Beck Depression Inventory (BDI-II) (Beck, Steer, & Brown, 1996) (Appendix 8) is a 21-item self-report depression screening measure and has become one of the most widely accepted measures for assessing the severity of depression in diagnosed individuals, and for detecting possible depression in normal populations (Beck et al., 1996). Depression is known to be a common consequence of stroke, and can affect cognitive functioning. There is also evidence to suggest that individuals who are depressed are biased in their judgments of emotions in others (Leppanen, Milders, Bell, Terriere, & Hietanen, 2004). It was therefore used in this study as an attempt to control for the possibility of depression affecting performance on the Eyes Test, which asks participants to identify the thoughts or emotions of others. Its ease of use was also a consideration.

The BDI was originally developed for research purposes, but is used extensively in clinical settings. Each item deals with a particular aspect of the experience and symptoms of depression (cognitive, affective, and somatic) and invites subjects to rate their own experience over the preceding two weeks. Each item contains four statements of graded severity expressing how a person might think or feel about the aspect of depression under consideration (Lezak et al., 2004). The score is the sum of all the selected statements with the maximum score being 63. The higher the overall score the more depressed the patient is likely to be. These criteria are only guidelines, however, and clinical judgement was also used in deciding whether an individual was indeed suffering from a depressive disorder.

It was also taken into consideration that the BDI-II, despite revision, has inherent problems when being used with elderly subjects. As Kaszniak and Allender (1985) highlight, seven of the 21 items refer to somatic symptoms increasing the possibility of misinterpretations when the patient has physical ailments (e.g. fatigability), as was the case with many of the stroke participants in this study. Therefore, care was taken to emphasise to subjects that they were being asked to consider changes in their experience during the preceding two weeks, and not in relation to how things used to be prior to having had a stroke. In line with the test manual the BDI was administered orally on some occasions; the researcher read out loud all statements from each group of statements, and then read back the statement corresponding to the number given by the examinee to confirm the statement selected. In establishing/investigating the psychometric properties of the BDI-II, a total sample of 620 individuals were recruited from 4 psychiatric outpatients clinics and 1 local

college (age range 13-86) (Beck et al., 1996). The manual reports significant test-retest correlations of .93 and findings indicative of robust convergent and discriminant validity (Beck et al., 1996).

2.4 Procedure

2.4.1 Stroke Group

Potential participants were those individuals with a diagnosis of stroke admitted to two stroke rehabilitation wards at Woodend Hospital, Aberdeen, during the time of the study. In collaboration with the Consultant Physicians, potential participants were identified. Using a sheet attached to the front of each patient's medical notes with a tick box (Yes/No), the Senior House Officer (SHO) or Medical Support Nurse (MSN) was asked to indicate whether the patient met the inclusion criteria. The SHO or MSN was then asked to approach the patient to ask if they would be happy for the principal investigator to speak to them further about the study. During this, the SHO or MSN briefly outlined the rationale for the study and provided a study information sheet (Appendix 9). The information sheet, as well as explaining the purpose of the study, also highlighted issues of consent, confidentiality, and the voluntary nature of the study. If the individual agreed, the researcher met with them to fully explain the study and answer any questions. Potential participants were then given up to one week to consider the information provided, and whether they wished to take part. Individuals were encouraged to speak to staff, family or friends about taking part in the study. It was also pointed out that even if they agreed, they could still withdraw from the study at any time, without having to give an explanation, and without this affecting their ongoing care and treatment.

2.4.2 Control Group

Participants in the control group comprised of 40 individuals recruited from a local community group (local church). Every effort was made to match these individuals with stroke group participants in terms of sex, age, and years of education. The inclusion criteria were adults with no reported neurological conditions and the exclusion criteria were the same as that described for the stroke group participants. Potential participants were provided with the same information regarding the study as the stroke patients, although changes were made regarding why they had been asked to participate, and with regards to what they would be required to do (Appendix10).

2.4.3 Administration

All stroke participants were seen individually in a private room to ensure confidentiality, and to avoid the noise and distractions from the ward environment. They were all seen on only one occasion, and length of testing time varied between 35 minutes and 65 minutes depending on ability. The measures were administered in accordance with the relevant manual instructions, although the Eyes Test was modified slightly by asking the participant to read out loud or point to each of the four words before making their choice. This was in order to compensate for the possible presence of visual neglect, which commonly occurs following stroke. The researcher was then more confident in the results obtained. Similarly, some individuals in the stroke group suffered from mild expressive dysphasia ($n = 7$), and it was therefore not appropriate to administer some of the other tasks, such as the NART and verbal fluency test. DEX questionnaires (independent rater) were

completed by either the named nurse or a member of the therapy team, believing them to have the most contact, and therefore the most reliable views on the patient's behaviour. The tasks were randomly presented to minimise order effects, although the NART was always administered after the verbal fluency task. This was to prevent the possibility of participants using words from the NART to enhance verbal fluency performance.

All the control participants were seen in their own home for convenience. In the control group, participants were asked during interview to disclose whether they had a current or past history of diagnosis or treatment for psychiatric or medical conditions in order to assess suitability for inclusion in the study. The researcher asked specifically about mood disorders, and enquired about factors associated with the risk of stroke (e.g. hypertension, high cholesterol, head injuries etc.).

All measures were administered to control participants, apart from the DEX questionnaires, which were only administered to those with stroke and their named nurse or therapist. In addition to verbal consent, written consent was provided by all participants (Appendix 11)

2.5 Ethical Considerations

A number of ethical issues were considered prior to undertaking this study and great care was taken to avoid causing distress to any of the participants. Although participants would not have been considered 'vulnerable' in the formal sense (i.e. children; individuals with a learning disability; individuals incapable of informed

consent), the researcher still considered stroke participants, in particular, to be a vulnerable group. Primarily this was because stroke participants, many of whom were elderly, were viewed by the investigator as 'recovering from illness'. Issues such as pain and fatigue, which are common symptoms following stroke, were also seriously borne in mind

It was also taken into account that, on occasion, neuropsychological assessments can cause some stress to patients. It was therefore planned to stop testing if this occurred. However, on no occasion did this happen and most participants gave positive feedback about the experience. Finally, the questionnaires and other measures used in this study were not thought by the investigator to be of a sensitive, embarrassing or upsetting nature. However, it was considered possible that individuals could react in unexpected ways, and become stressed or upset as a result. Thankfully, this situation did not arise, but testing would have been discontinued if it had.

This study was granted full ethical approval by Grampian Research Ethics Committee, and registered with the Grampian Research and Development department (Appendix 12).

2.6 Data Analysis

All statistical analyses were run using the Statistical Packages for the Social Sciences (SPSS), version 12. Gravetter and Wallnau (1996) outline that in situations where there is unequal number of participants in each group, as was the case in this study, ANOVA still provides a valid test when the discrepancy between sample sizes is not

extreme. In addition, the assumptions for using parametric tests were met, therefore one-way analyses of variance (ANOVA), and analyses of covariance (ANCOVA) were run for comparisons. Sheffe's post hoc analyses were also run. Gravetter and Wallnau (1996) highlight that this test uses an extremely cautious method for reducing the risk of Type 1 error and because of this has the distinction of being one of the safest of all possible post hoc tests. Pearson's product moment correlational analyses were also conducted in order to determine the associations between the variables of interest in this study. The effect size of the correlation coefficients is based upon the definitions provided by Cohen & Holiday (1982):

- .00 to .19 is very low
- .20 to .39 is low
- .40 to .69 is modest
- .70 to .89 is high
- .90 to 1.00 is very high

2.7 Statistical Power

One-way ANCOVA was carried out using right hemisphere lesion, left hemisphere lesion, and control as the 3 groups and executive function as covariant. Results of Happe, Brownell and Winner's (1999) study suggest effect size will be very large and taking power 0.8 and $\alpha = .05$ groups of size 21 would be required to detect a statistically significant difference if they are equal (Cohen, 1992). A covariant was thought unlikely to reduce power, but practical considerations made it necessary to use unequal group sizes. Power was maintained by increasing the size of the control group.

CHAPTER THREE: RESULTS

3.0 RESULTS

The main aim of this study was to investigate a component of everyday social understanding commonly referred to as 'Theory of Mind' (ToM) in post-stroke individuals. A second aim was to investigate performance of stroke patients on measures of executive function compared to controls. The third aim of this study was to investigate the relationship between ToM ability and executive function in post-stroke individuals. Therefore, total scores for each of the measures in the battery of tests were computed before analyses were conducted. Scaled or *t* scores were also computed for the measures that provided appropriate information to enable this function to be carried out. Prior to statistical analysis, exploratory data analysis was conducted which demonstrated that distributions were sufficiently normal for assumptions of parametric statistics to be met.

3.1 Participants

3.1.1 Group Descriptive Statistics

The experimental group consisted of 30 stroke patients (15 right-sided lesions (male, *n* = 7; female, *n* = 8) and 15 left-sided lesions (male, *n* = 7; female, *n* = 8) recruited from two inpatient stroke rehabilitation wards. The control group comprised 40 individuals (male, *n* = 18; female, *n* = 22) recruited from a local community group.

(a) Handedness

Handedness was determined by self-report and all participants were right-handed with the exception of one male in the control group.

(b) Sex

Table 1 shows the number of males and females in each of the groups. As this table demonstrates, relatively equal numbers of males and females were represented in each of the groups.*

Table 1. Total number of males and females in each of the three groups.

			GROUP			Total
			control	Right-sided lesion	Left-sided lesion	
SEX	male	n	18	7	7	32
	female	n	22	8	8	38
Total		N	40	15	15	70

* Performing a chi-square analysis confirmed there were no significant differences between frequencies of males and females within each of the groups, $\chi^2 (2, n = 70) = .019, p = .990$. This confirmed both sexes were relatively well represented thereby reducing the risk of a sex (gender) bias in performance on Theory of Mind tasks.

(c) Years of Education, Age and NART predicted IQ

Every effort was made to match the stroke and control participants in terms of years of education, age and IQ (Table 2).

Table 2. Descriptive statistics for age, NART predicted IQ, and years of education

		Right-sided lesion	Left-sided lesion	Controls	TOTAL
Years of education	Mean	11.73	10.87	12.13	11.77
	N	15	15	40	70
	Std. Deviation	3.08	2.26	3.54	3.21
	Minimum	9	8	8	8
	Maximum	19	17	20	20
Age	Mean	67.80	67.73	66.62	67.11
	N	15	15	40	70
	Std. Deviation	14.14	9.99	12.74	12.36
	Minimum	31	50	30	30
	Maximum	86	84	86	86
NART predicted IQ	Mean	105.40	101.38	108.87	107.10
	N	15	8	40	63
	Std. Deviation	11.22	12.08	9.47	10.40
	Minimum	90	86	89	86
	Maximum	127	121	124	127

Table 2 demonstrates that the control group had slightly more years of education than both the right-sided lesion group (RSL) and left-sided lesion group (LSL). Similarly, mean NART predicted IQ was greater in the control group compared to both RSL group and LSL group. In terms of age, the groups did not appear to differ significantly. Analyses of variance (ANOVA) indicated no significant differences between the groups in terms years of education ($F(2, 67) = 0.83, p = 0.44$ ns), age ($F(2, 67) = 0.07, p = 0.93$ ns), or NART predicted IQ ($F(2, 67) = 2.06, p = 0.14$ ns).

(d) Depression

As outlined in Section 2.3.7, depression is known to globally affect cognitive function, and is a common consequence of stroke. Therefore the Beck Depression Inventory (BDI-II) was used to allow depression to be controlled for. The findings relating to depression for each of the groups are presented in Table 3.

Table 3. Descriptive statistics for the BDI measure of depression.

	Group	N	Mean	SD	Minimum	Maximum
BDI score	control	40	4.22	4.05	0	17
	right-sided lesion	15	5.20	7.52	0	28
	left-sided lesion	15	4.73	4.17	0	18

BDI = Beck Depression Inventory

As Table 3 shows, the right-sided lesion group scored slightly higher on the BDI compared to the left-sided lesion and control groups. However, Analysis of Variance (ANOVA) revealed that the difference between groups was not significant, $F(2, 67) = 0.22$, $p = .082$ ns. The frequencies of each BDI category are shown in Table 4.

Table 4. Frequencies of BDI categories representing severity of depression for stroke and control groups'.

		group			Total
		control	Right-sided lesion	Left-sided lesion	
BDI category	minimal	39	14	14	67
	mild	1	0	1	2
	moderate	0	1	0	1
	severe	0	0	0	0
Total		40	15	15	70

BDI = Beck Depression Inventory

It can be seen in Table 4 that the majority ($n = 67$) of the sample scored within the minimal range. This classification is given even for those who score zero on the BDI measure. Two individuals fell within the mild range for depression according to their BDI score; one in the control group and one in the left-sided lesion group.

The maximum score of 28 (Table 3) and the corresponding moderate classification of depression (Table 4) in the right-sided lesion group is representative of an outlier within the entire sample. This case was not excluded from further analyses as it was believed to accurately reflect the individual's feelings at the time of testing. However, this individual, despite scoring within the moderate range for depression on the BDI, did not present at interview as clinically depressed. Further qualitative examination of the data for this case supported this view. This individual's performance on tasks was not globally impaired, and on occasion, their performance was in line with that of control participants.

3.1.2 Stroke Group Characteristics

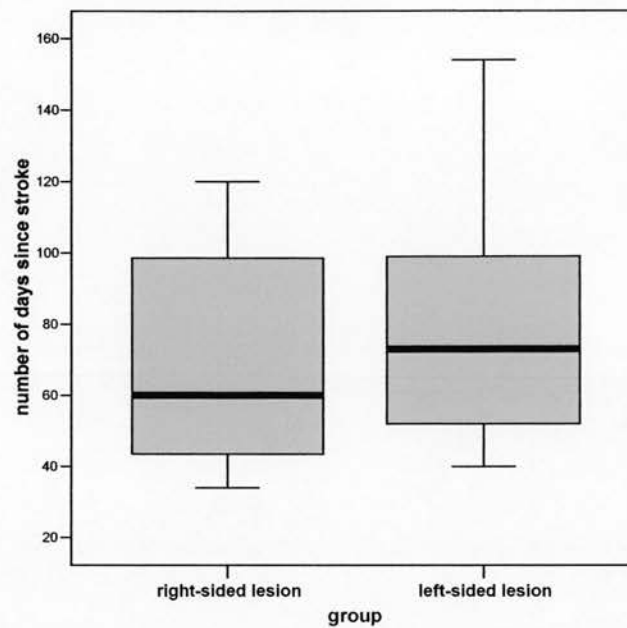
(a) Time Since Stroke

Time since stroke information was computed by totalling the number of days that had passed between date of stroke and date of testing. The mean number of days since stroke for both the right-sided lesion and left-sided lesion groups is presented in Table 5. This finding is also shown graphically in Figure 1.

Table 5. Mean number of days since stroke for the right-sided lesion and left-sided lesion groups

Group	Mean	N	SD	Minimum	Maximum
Right-sided lesion	71.0	15	32.48	34	120
Left-sided lesion	77.4	15	32.48	40	154
Total	74.2	30	32.08	34	154

Figure 1. Boxplots showing the range and median number of days since stroke for both stroke groups (right-sided lesion, n = 15; left-sided lesion, n = 15).



A one-way ANOVA found no statistically significant difference between the two stroke groups (right-sided lesion ($M = 71.00$, $SD = 32.48$, range, 34-120); left-sided lesion ($M = 77.47$, $SD = 22.48$, range, 40-154) in terms of mean time since stroke ($F(1, 28) = 0.30$, $p = 0.59$ ns), therefore, this variable was not included in further analyses.

(b) Location of Lesion

Stroke group participants were classified as having sustained either a right-sided lesion (RSL) or left-sided lesion (LSL) based on the type of stroke (Oxford Classification, see section 1.1.4 in Introduction section) reported in the medical notes. The frequencies of each type of stroke are shown in Table 6.

Table 6. Frequencies of Oxford Stroke classifications as a function of side of lesion and sex of participant.

Oxford classification	Sex		Total
	Male	Female	
Right TACI	4	1	5
Left TACI	2	2	4
Right PACI	1	5	6
Left PACI	1	2	3
Right LACI	2	2	4
Left LACI	3	3	6
Left HAEM	1	1	2
Total	14	16	30

TACI = Total Anterior Circulation Infarct; PACI = Partial Anterior Circulation Infarct; LACI = Lacunar Infarct; HAEM = Haemorrhagic stroke.

NB: Haemorrhage is not considered within the Oxford Classification (Bamford & Sandercock, 1991), but is included in this table for ease of comparisons.

Following Burgess and Shallice (1996), stroke participants were also classified as anterior (n = 13) if the lesion involved the frontal lobe, and as posterior (n = 17) if there was no frontal involvement. Lesion evidence was based on the medical interpretation of clinical radiological MRI or CT reports and information documented in patients' medical notes. These findings are shown in table 7.

Table 7. Anterior and Posterior classification for stroke participants.

		sex		Total
		male	female	
location of lesion	Anterior	7	6	13
	Posterior	7	10	17
Total		14	16	30

The anterior/posterior distinction was further broken down to include the hemispheric location of lesion. This information can be seen in Table 8.

Table 8. Frequency of Anterior and posterior lesions as a function of hemispheric location.

		sex		Total
		male	female	
specific lesion site	right anterior	4	2	6
	left anterior	3	4	7
	right posterior	3	6	9
	left posterior	4	4	8
Total		14	16	30

3.2 Theory of Mind (ToM) Task

3.2.1 Right versus Left-sided lesions

The Eyes Test

In accordance with the aim of investigating the differences between the groups on the Eyes Test, which is believed to measure ToM ability, scores were analysed in terms of group (right-sided lesion (RSL) $n=15$, left-sided lesion (LSL) $n=15$, and control $n=40$). It was hypothesised that individuals with RSLs would perform significantly worse on the Eyes Test than either individuals with LSLs or healthy controls. Descriptive statistics are shown in Table 9.

Table 9. Descriptive statistics of performance on the Eyes Test

Group	N	Mean	SD	95% Confidence Interval for mean		Minimum	Maximum
				Lower bound	Upper bound		
Control	40	16.43	3.37	15.35	17.50	10	24
Right- sided lesion	15	10.07	4.11	7.79	12.34	5	18
Left-sided lesion	15	15.27	2.99	13.61	16.92	11	23
Total	70	14.81	4.26	13.80	15.83	5	24

The confidence intervals demonstrate that the left-sided lesion group and the control group overlap, indicating that there are no important differences between these two groups' performance on the Eyes Test. The right-sided lesion group, however, not only has a lower sample mean ($M = 10.07$, $SD = 4.11$) of correct ToM judgments

than both the left-sided lesion group ($M = 15.27$, $SD = 2.99$) and controls ($M = 16.43$, $SD = 3.37$), but the confidence interval for the mean does not overlap with them. As expected, this suggests that there is a difference in performance on the Eyes Test between the right-sided lesion group and both the left-sided lesion group and the control group.

A one-way ANOVA comparing the three groups on the Eyes Test revealed the difference between groups was significant, $F(2, 67) = 18.50$, $p < .001$. This represented an effect size (partial η^2) of 0.356, showing that nearly 36% of the variation in performance on the Eyes Task can be accounted for by group (i.e. presence and hemispheric location of lesion).

Further examination using Scheffe's post-hoc tests confirmed that the right-sided lesion group performed significantly worse than the other two groups (left-sided lesions and Control), who did not differ significantly from each other (Table 10). Thus, the hypothesis that individuals with right-sided lesions would perform significantly worse on The Eyes Test compared to individuals with left-sided lesions and controls has been supported.

Table 10. Sheffe's post-hoc analysis comparing right-sided lesion, left-sided lesion and control groups' performance on the Eyes Test

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	Right-sided lesion	6.358*	1.050	.001	3.73	8.99
	Left-sided lesion	1.158	1.050	.547	-1.47	3.79
Right-sided lesion	Left-sided lesion	-5.200*	1.266	.001	-8.37	-2.03

*The mean difference is significant at the .01 level.

Eyes Control Task

It was hypothesised that no difference would be found between the groups' performance on the Eyes Control Task. Mean scores for each of the groups' performance on the Eyes Control Task is shown in Table 11.

Table 11. Descriptive statistics of performance on the Eyes Control Test for right- and left-sided stroke and control groups

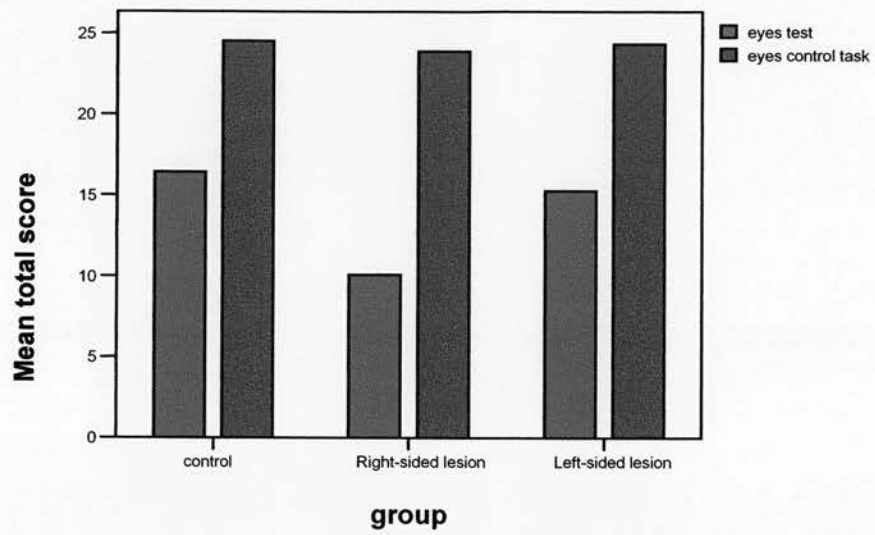
Group	N	Mean	SD	95% Confidence Interval for mean		Minimum	Maximum
				Lower bound	Upper bound		
Control	40	24.50	0.85	24.23	24.77	22	25
Right-sided lesion	15	23.87	1.96	22.78	24.95	19	25
Left-sided lesion	15	24.33	1.35	23.59	25.08	20	25
Total	70	24.33	1.27	24.03	24.63	19	25

Table 11 demonstrate that performance on the Eyes Control Task did not appear to differ greatly between the groups as it did on the theory of mind Eyes Test (see Table 7) with the mean scores for the right-sided lesion group ($M = 23.87$, $SD = 1.96$), being similar to that of the left-sided lesion group ($M = 24.33$, $SD = 1.35$) and controls ($M = 24.50$, $SD = 0.85$). The maximum score on this task was 25, therefore, the findings shown in Table 11 also demonstrate an apparent ceiling effect.

Indeed, ANOVA revealed no significant effect of group on the Eyes Control Task, $F(2, 67) = 1.37$, $p = .26$ ns, which is the result that was predicted. The differences in performance between the groups on both the Eyes and Eyes Control Tests can be seen in Figure 2.*

* A repeated measures ANOVA was also conducted which revealed a significant effect for group x task interaction, $F(4, 65) = 8.33$, $p < .001$. In order to clarify the significant differences, separate one-way ANOVAs were run comparing the groups' performances on the ToM Eyes and ToM control tests, these analyses are reported in the text, p84 - 90.

Figure 2. Mean scores on the Eyes Test and Eyes Control Task.



3.2.2 Anterior versus Posterior lesions

Differences between anterior and posterior stroke groups' performance on the Eyes Test were also examined. It was hypothesised that individuals with anterior positioned lesions would perform significantly worse on The Eyes Test than either individuals with posterior lesions or healthy controls. A summary of the descriptive statistics is displayed in Table 12.

Table 12. Descriptive statistics of performance on the Eyes Test for anterior and posterior stroke and control groups

Group	N	Mean	SD	95% Confidence Interval for mean		Minimum	Maximum
				Lower bound	Upper bound		
Control	40	16.42	3.37	15.35	17.50	10	24
Anterior lesion	13	13.00	4.02	10.57	15.43	5	19
Posterior lesion	17	12.41	4.80	9.95	14.88	5	23
Total	70	14.81	4.26	13.80	15.83	5	24

Although the anterior stroke group performed slightly better than the posterior stroke group, both stroke groups' performance was poorer than the control group.

Analysis of Variance demonstrated a significant difference in scores on the Eyes Test between anterior stroke, posterior stroke and control groups $F(2, 67) = 8.15, p < .001$. This represented an effect size (partial η^2) of .196, showing that nearly 20% of the variation in performance on the Eyes Task can be accounted for by group. Sheffe's post hoc comparisons were conducted to determine which pairs of group scores were significantly different (Table 13)

Table 13. Post Hoc comparisons between anterior stroke group, posterior stroke group and control group on the Eyes Test

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	Anterior lesion	3.42*	1.24	.027	0.33	6.52
	Posterior lesion	4.01*	1.12	.003	1.20	6.82
Anterior lesion	Posterior lesion	0.59	1.43	.919	-2.99	4.16

*The mean difference is significant at the .05 level.

The results shown in Table 13 indicate that both the anterior and posterior stroke groups performed significantly worse than the control group on the Eyes Test, but did not differ significantly from each other. Therefore, the prediction that anterior lesions would be significantly more detrimental to performance on the theory of mind task compared to posterior lesions has not been supported.

Examination of the performance on the Eyes Control task between anterior and posterior stroke and control groups' was also performed (Table 14). It was hypothesised that there would be no difference in performance on this control task between groups.

Table 14. Descriptive statistics of performance on the Eyes Control Test for anterior and posterior stroke and control groups

Group	N	Mean	SD	95% Confidence Interval for mean		Minimum	Maximum
				Lower bound	Upper bound		
Control	40	24.50	0.85	24.23	24.77	22	25
Anterior lesion	13	24.62	1.12	23.94	25.29	21	25
Posterior lesion	17	23.71	1.93	22.71	24.70	19	25
Total	70	24.33	1.27	24.03	24.63	19	25

As the results in Table 14 show, the anterior stroke group performed marginally better on the Eyes Control Task than the posterior stroke and control groups, although the control group performed slightly better than the posterior stroke group. However, these differences were slight, and as predicted Analysis of Variance demonstrated no significant difference between the groups, $F(2, 67) = 2.88, p = .06$ ns.

3.2.3 Comparisons of Right Anterior, Left Anterior, Right Posterior and Left Posterior stroke

Exploratory Results

Analyses were also conducted to examine the differences between right anterior, left anterior, right posterior, left posterior stroke and control groups' performance on the Eyes Test. This investigation was exploratory to investigate whether any specific lesion site was more detrimental to theory of mind (ToM) ability compared to others. No specific hypotheses were made. A summary of the descriptive statistics is displayed in Table 15.

Table 15. Descriptive statistics of performance on the Eyes Test for right anterior, left anterior, right posterior and left posterior stroke and control groups

Group	N	Mean	SD	95% Confidence Interval for mean		Minimum	Maximum
				Lower bound	Upper bound		
Control	40	16.42	3.37	15.35	17.50	10	24
Right anterior lesion	6	9.50	2.74	6.63	12.37	5	12
Left anterior lesion	7	16.00	1.83	14.31	17.69	14	19
Right posterior lesion	9	10.44	4.95	6.64	14.25	5	18
Left Posterior lesion	8	14.62	3.74	11.50	17.75	11	23
Total	70	14.81	4.26	13.80	15.83	5	24

Table 15 demonstrates that there were differences between the mean performances on the Eyes Test for each of the groups. The left anterior lesion group and the right and left posterior lesion groups performed less well than the control group. However, the right anterior lesion group's performance was the poorest compared to all other groups.

Analysis of Variance demonstrated a significant difference in performance scores on the Eyes Test between right anterior, left anterior, right posterior, and left posterior stroke and control groups, $F(4, 65) = 9.30, p < .001$. This represented an effect size

(partial η^2) of .364, showing that nearly 36% of the variation in performance on the Eyes Task can be accounted for by group (i.e. presence and hemispheric location of lesion). Sheffe's post hoc comparisons were conducted to determine which pairs of group scores were significantly different (Table 16).

Table 16. Post Hoc comparisons between right anterior, left anterior, right posterior, left posterior stroke and control groups on the Eyes Test.

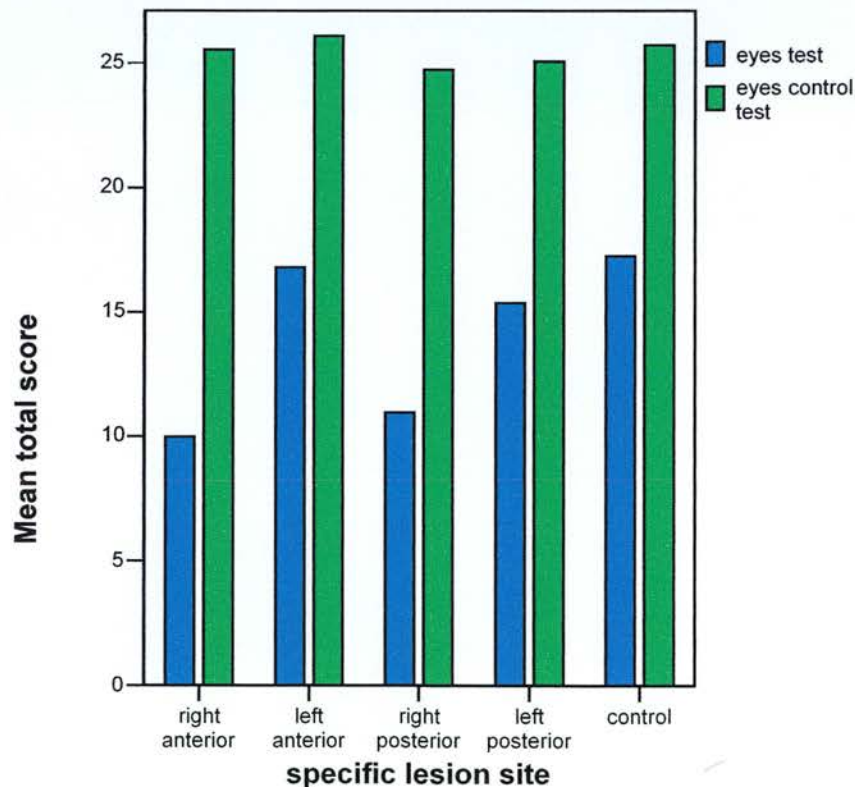
(I) group	(J) group	Mean difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	right anterior	6.92*	1.53	.001	2.07	11.78
	left anterior	0.42	1.43	.999	-4.12	4.97
	right posterior	5.98*	1.29	.001	1.89	10.07
	left posterior	1.80	1.35	.778	-2.50	6.10
Right Anterior	left anterior	-6.50*	1.95	.003	-12.67	-0.33
	right posterior	-0.94	1.84	.992	-6.79	4.90
	left posterior	-5.12	1.89	.132	-11.11	0.86
Left Anterior	right posterior	5.56	1.76	.052	-0.03	11.14
	left posterior	1.38	1.81	.965	-4.36	7.11
Left posterior	right posterior	4.18	1.70	.209	-1.21	9.57

* The mean difference is significant at the .01 level.

The results shown in Table 16 indicate that the performance of the right anterior group on the Eyes Test differed significantly from that of the left anterior and control groups. The right posterior group's performance differed significantly from the controls, but not from the right anterior group. No other significant differences were found.

Comparison of these groups' performance on the Eyes Control test revealed no significant differences between the groups $F(4, 65) = 1.63$, $p = .18$ ns. These findings are shown in Figure 3.

Figure 3. Mean scores on the Eyes Test and Eyes Control Test for the control group and in relation to specific site of lesion for stroke groups.



3.3 Executive Function

In accordance with the aim of investigating the differences between the groups on executive function tasks, scores were analysed in terms of the right/left lesion dimension and anterior/posterior lesion dimension. More specific comparisons were not explored. This was due to the fact that post hoc analyses would not have been possible due to missing data ($n = 7$) for the left anterior group owing to mild expressive dysphasia.

Standardised scores (i.e. adjusted for age and education) for The Brixton Task and Verbal Fluency tasks were used in analyses.

3.3.1 Right versus Left-sided Stroke

It was hypothesised that both stroke groups (right-sided and left-sided lesions) would be equally impaired on measures of executive function. Descriptive statistics for the right and left-sided lesion groups' performance on The Brixton Task and letter and category Verbal Fluency tasks are shown below. Table 17 highlights missing data for 7 individuals in the left-sided lesion group on tasks of verbal fluency (letter and category trials). These individuals suffered from mild expressive dysphasia and it would not have been appropriate to administer these tests given their reliance on intact verbal ability. The Brixton Task has no verbal demands and was completed by all participants.

Table 17. Descriptive statistics for right and left-sided lesion and control groups on measures of executive function

Measure	Group	N	Mean	Std. Deviation	Minimum	Maximum
The Brixton Task (scaled score)	control	40	5.73	1.71	2	10
	right-sided lesion	15	3.27	2.52	1	7
	left-sided lesion	15	3.47	2.10	1	7
letter fluency (<i>t</i> score)	control	40	50.35	9.71	31	80
	right-sided lesion	15	36.93	12.43	17	51
	left-sided lesion	8	42.00	15.76	24	69
category fluency (<i>t</i> score)	control	40	52.40	8.48	32	74
	right-sided lesion	15	37.67	10.62	15	53
	left-sided lesion	8	40.75	13.24	24	56

(a) The Brixton Task

Table 17 demonstrates that the control groups' mean scaled score for the Brixton Task was slightly higher than both the right-sided lesion and left-sided lesion groups. However, the left-sided lesion group performed marginally better than the right-sided lesion group.

As expected, Analysis of Variance confirmed a significant difference in performance on the Brixton Task between the groups, $F(2, 67) = 12.11, p < .001$. This represented an effect size (partial η^2) of .265, showing that nearly 27% of the variation in performance on the Brixton Task can be accounted for by lesion group. Sheffe's post hoc comparisons were conducted to determine which pairs of group scores were significantly different (Table 18).

Table 18. Sheffe's post-hoc analysis comparing right-sided lesion, left-sided lesion and control groups' performance on the Brixton Task

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	Right-sided lesion	2.46*	0.60	.001	0.95	3.96
	Left-sided lesion	2.26*	0.60	.002	0.75	3.76
Right-sided lesion	Left-sided lesion	-0.20	0.73	.963	-2.0	1.62

*The mean difference is significant at the .01 level.

The results shown in Table 18 confirm that the performance of both lesion groups on the Brixton Task was significantly impaired compared to that of the control group, thus supporting the hypothesis that both stroke groups would be equally impaired compared to controls.

(b) Verbal Fluency (Letter)

Table 17 shows that controls performed better on the verbal fluency task than either of the stroke groups with their mean t score being greater than right-sided lesion and left-sided lesion groups. However, the left-sided lesion group performed slightly better than the right-sided lesion group.

Analysis of Variance demonstrated a significant difference between the groups $F(2,60) = 8.38, p < .01$. This represented an effect size (partial η^2) of .218, showing that nearly 22% of the variation in performance on the letter fluency task can be accounted for by lesion group.

As predicted, Sheffe’s post hoc comparisons (Table 19) revealed that both right and left-sided lesion groups differed significantly from controls, but did not differ significantly from each other.

Table 19. Sheffe’s post-hoc analyses comparing right-sided lesion, left-sided lesion and control groups’ performance on the letter fluency task.

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	Right-sided lesion	13.42*	3.40	.001	4.87	21.96
	Left-sided lesion	8.35	4.35	.168	-2.58	19.28
Right-sided lesion	Left-sided lesion	-5.07	4.92	.591	-17.42	7.29

* The mean difference is significant at the .01 level.

(c) Verbal fluency (Category)

Table 17 shows that controls performed better on the category fluency task than either of the stroke groups with their mean t score ($M = 52.40$, $SD = 8.48$) being greater than right-sided lesion ($M = 37.67$, $SD = 10.62$) and left-sided lesion ($M = 40.75$, $SD = 13.24$) groups.

Analysis of Variance demonstrated a significant difference between the groups $F(2,60) = 14.84$, $p < .01$. This represented an effect size (partial η^2) of .331, showing that 33% of the variation in performance on the category task can be accounted for by lesion group. As predicted, Sheffe's post hoc comparisons (Table 20) revealed that similar to the performance on the letter fluency task, both right and left-sided lesion groups differed significantly from controls, and did not differ significantly from each other on the category fluency task.

Table 20. Sheffe's post-hoc analysis comparing right-sided lesion, left-sided lesion and control groups' performance on the category fluency task

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	Right-sided lesion	14.73*	2.93	.001	7.39	22.08
	Left-sided lesion	11.65*	3.74	.011	2.25	21.05
Right-sided lesion	Left-sided lesion	-3.08	4.23	.768	-13.71	7.54

* The mean difference is significant at the .01 level.

3.3.2 Anterior versus Posterior Stroke

It was hypothesised that individuals with anterior lesions would be more impaired on measures of executive function compared to individuals with posterior lesions and controls. Descriptive statistics for the anterior and posterior lesion groups' performance on The Brixton Task and letter and category Verbal Fluency tasks are shown in Table 21. Seven individuals in the anterior lesion group had missing data for tasks of verbal fluency. These were the same individuals with missing data in the left sided-lesion stroke group due to expressive dysphasia.

Table 21. Descriptive statistics for anterior and posterior lesion and control groups on measures of executive function.

Measure	Group	N	Mean	Std.	Minimum	Maximum
				Deviation		
The Brixton Task (scaled score)	control	40	5.73	1.71	2	10
	anterior lesion	13	2.69	1.80	1	6
	posterior lesion	17	3.88	2.52	1	7
letter fluency (<i>t</i> score)	control	40	50.35	9.71	31	80
	anterior lesion	7	37.57	12.01	19	50
	posterior lesion	16	39.19	14.51	17	69
category fluency (<i>t</i> score)	control	40	52.40	8.48	32	74
	anterior lesion	7	44.00	8.50	30	56
	posterior lesion	16	36.44	11.63	15	55

(a) The Brixton Task

Table 21 demonstrates that the control groups mean scaled score for the Brixton Task was higher than both the anterior and posterior lesion groups. However, as predicted, the anterior lesion group scored lower than the posterior lesion group indicating poorer performance on this task.

Analysis of Variance demonstrated a significant difference in performance on the Brixton Task between the groups $F(2, 67) = 13.92, p < .01$. This represented an effect size (partial η^2) of .294 indicating that 29% of the variance in performance can be accounted for by lesion group. Sheffe's post hoc comparisons demonstrated that both anterior and posterior lesion groups were significantly impaired on the Brixton task compared to the control group, but did not differ significantly from each other (Table 22). Thus, the above hypothesis has not been supported.

Table 22. Sheffe's post hoc analyses comparing anterior and posterior lesion and control groups' performance on the Brixton Task.

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	anterior lesion	3.03*	0.62	.001	1.47	4.59
	posterior lesion	1.84*	3.74	.007	0.43	3.26
Anterior lesion	posterior lesion	-1.19	.718	.260	-2.99	0.61

* The mean difference is significant at the .01 level.

(b) Verbal Fluency (Letter)

As shown in Table 21, the mean t score for verbal fluency was lower in the anterior ($M = 37.57$, $SD = 12.01$) and posterior ($M = 39.19$, $SD = 14.51$) lesion groups compared to controls ($M = 50.35$, $SD = 9.71$). Table 21 also demonstrates that the anterior lesion group performed the poorest, although both stroke groups' performance fell within the impaired range. As expected, Analysis of Variance revealed these differences to be significant. $F(2, 60) = 7.77$, $p < .01$ represents an effect size (partial η^2) of .206, indicating that just over 20% of the variation in performance on the letter fluency task can be accounted for by lesion group.

Sheffé's post hoc comparisons were conducted to determine which pairs of group scores were significantly different (Table 23). Table 23 shows that both anterior and posterior lesion groups differed significantly from controls, but did not differ significantly from each other. This was an unexpected finding that does not support the hypothesis that anterior brain lesions would be more detrimental to performance on executive function tasks compared to posterior brain lesions.

Table 23. Sheffe’s post hoc analyses comparing anterior and posterior lesion and control groups’ performance on the letter fluency task.

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	anterior lesion	12.78*	4.64	.028	1.13	24.43
	posterior lesion	11.16*	3.35	.006	2.75	19.58
Anterior lesion	posterior lesion	-1.62	5.13	.952	-14.50	11.27

* The mean difference is significant at the .05 level.

(c) Verbal Fluency (Category)

As demonstrated in Table 21, controls ($M = 52.40$, $SD = 8.48$) performed better on the category fluency task compared to both anterior ($M = 44.00$, $SD = 8.50$) and posterior ($M = 36.44$, $SD = 11.63$) lesion groups. However, in contrast to the stroke groups’ performances on the letter fluency task, the posterior group’s performance was the poorest on the category fluency task and the only stroke group to perform within the impaired range. Interestingly, the anterior group performed within the average range, albeit at the low average end of the scale.

As expected, Analysis of Variance demonstrated a significant difference between the groups $F(2, 60) = 16.75$, $p < .01$. This represented an effect size (partial η^2) of .358, showing that nearly 36% of the variation in performance on the category fluency task can be accounted for by lesion group. Sheffe’s post hoc comparisons were conducted to determine which pairs of group scores were significantly different (Table 24).

Table 24. Sheffe's post hoc analyses comparing anterior and posterior lesion and control groups performance on the category fluency task.

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	anterior lesion	8.40	3.88	.105	-1.34	18.14
	posterior lesion	15.96*	2.80	.001	8.93	22.99
Anterior lesion	posterior lesion	7.56	4.29	.220	-3.21	18.33

* The mean difference is significant at the .01 level.

The results shown in Table 24 indicate that the only significant difference on the category fluency task was between the posterior lesion group's performance and controls. This again was an unexpected finding that does not support the hypothesis that individuals with anterior lesions would perform significantly worse on tasks of executive function compared to individuals with posterior lesions.

3.3.3 Dysexecutive Questionnaire (DEX)

The DEX questionnaire was used to investigate the degree of awareness stroke individuals' had in relation to executive function difficulties. Individuals rated themselves in terms of dysexecutive problems and were additionally rated by someone who knew them well (see section 2.3.6 in Method section). Comparisons between right and left-sided lesion groups and anterior and posterior lesion groups were undertaken. Descriptive statistics are presented in Table 25.

Table 25. Descriptive statistics for right and left-sided lesion and anterior and posterior lesion groups on the Dysexecutive questionnaire (DEX).

	Measure	Group	N	mean	SD	minimum	maximum
RIGHT Vs LEFT	DEX* self rating	right-sided lesion	15	11.53	9.17	1	28
		left-sided lesion	15	11.27	8.66	2	36
	DEX independent	right-sided lesion	15	12.27	10.76	1	43
		left-sided lesion	15	10.93	6.66	0	24
ANTERIOR Vs POSTERIOR	DEX self rating	anterior lesion	13	12.08	8.86	2	28
		posterior lesion	17	10.88	8.93	1	36
	DEX independent	anterior lesion	13	11.62	5.45	5	24
		posterior lesion	17	11.59	10.89	0	43

* DEX = Dysexecutive questionnaire; Self rating is completed by patient; Independent rating is the questionnaire completed by someone who has at least daily contact with the patient

(a) Right versus Left sided Stroke

It was hypothesised that individuals with right-sided stroke would score themselves significantly lower on the DEX compared to individuals with left-sided stroke and independent raters. However, this hypothesis was not supported. As Table 25 shows, the right-sided lesion stroke group rated themselves slightly higher on the DEX questionnaire compared to the left-sided lesion group, although this difference was not significant, $F(1, 28) = .08, p = .935$ ns. Independent raters also scored patients in the right-sided lesion group higher than those in the left-sided lesion group. Interestingly, the left sided lesion group scored themselves as having greater difficulties than the independent raters believed them to have.

(b) Anterior versus Posterior Stroke

It was hypothesised that individuals with anterior lesions, a group commonly associated with insight problems, would rate themselves significantly lower than individuals with posterior lesions. However, Table 25 shows that the anterior lesion group ($M = 11.62$) actually rated themselves as having more executive function related difficulties than the posterior group ($M = 11.59$) rated themselves to have. However, the difference between the groups was slight and found not to be not significant, $F(1, 28) = 1.3, p = .718$ ns. Similarly, the independent raters also scored the anterior lesion group as having slightly more difficulties than the group with posterior lesions. The range of scores shown in Table 25 suggest that those in the anterior group were perhaps less aware of their difficulties.

3.4 Theory of Mind (ToM) and Executive function

3.4.1 Correlational Analyses

It was hypothesised that amongst stroke patients there would be a significant and positive relationship between measures of executive function and ToM. There is debate in the theory of mind (ToM) literature as to whether ToM is an independent construct. It has been suggested that poor performance on ToM type tasks are attributable to deficits in executive function and that ToM is not a separate ability at all. In general, factors such as age, years of education, IQ and depression are also known to influence cognitive functioning. Therefore, to determine the direction and strength of associations between the variables in this study, Pearson product moment correlational analyses were conducted using the stroke participants' data only.

In particular, analyses included stroke participants' data on the Eyes Test, which is believed to measure ToM, and the Eyes Control Test that requires participants to indicate the sex and age of the person (see section 2.3.2 and 2.3.3). Similarly, stroke participants' performance data on the Brixton Task, Verbal Fluency task, and dysexecutive (DEX) questionnaire, routinely used as measures of executive functioning was also included. Age, IQ, and depression scores were also included in analyses to investigate their relationship with both the ToM and executive function tasks. The analyses revealed a number of significant correlations (see Appendix 13 for full analyses). However, only the most relevant and interesting findings will be reported (Table 26).

Table 26. Pearson correlations between the Eyes and Eyes Control tests, the Brixton Task, Verbal Fluency (letter and category fluency trials), Dysexecutive (DEX) questionnaire (self report), age, IQ and Beck depression Inventory (BDI – II).

		age	Brixton scaled score	Eyes Test total score	Eyes control total score	Letter fluency t score	Category fluency t score	NART predicted IQ	DEX self rating	BDI
age	Pearson Correlation	1								
	Sig. (2-tailed)	.								
	N	30								
Brixton scaled score	Pearson Correlation	-.46**	1							
	Sig. (2-tailed)	.010	.							
	N	30	30							
Eyes Test total score	Pearson Correlation	-.42*	.39*	1						
	Sig. (2-tailed)	.021	.035	.						
	N	30	30	30						
Eyes control total score	Pearson Correlation	-.34	.19	.25	1					
	Sig. (2-tailed)	.068	.316	.177	.					
	N	30	30	30	30					
Letter fluency t score	Pearson Correlation	.12	.20	.23	.19	1				
	Sig. (2-tailed)	.588	.369	.294	.377	.				
	N	23	23	23	23	23				
Category fluency t score	Pearson Correlation	-.17	.20	.33	.37	.72**	1			
	Sig. (2-tailed)	.447	.357	.126	.085	.001	.			
	N	23	23	23	23	23	23			
NART ⁺ predicted IQ	Pearson Correlation	-.06	.44*	.26	-.10	.36	.08	1		
	Sig. (2-tailed)	.784	.034	.234	.652	.094	.711	.		
	N	23	23	23	23	23	23	23		
DEX ⁺⁺ self rating	Pearson Correlation	.22	.01	-.11	-.29	.181	.06	-.02	1	
	Sig. (2-tailed)	.247	.945	.548	.113	.409	.785	.925	.	
	N	30	30	30	30	23	23	23	30	
BDI	Pearson Correlation	-.04	.01	.29	-.34	-.07	-.10	.19	.08	1
	Sig. (2-tailed)	.815	.954	.120	.062	.748	.653	.376	.657	.
	N	30	30	30	30	23	23	23	30	30

** Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

⁺ National Adult Reading test

⁺⁺ Dysexecutive Questionnaire

As expected, Table 26 demonstrates that performance on the theory of mind Eyes Test was moderately related to performances on the Brixton task ($r = .39, p < .01$, two-tailed). However, although performances on the letter fluency ($r = .23, p = .294$ ns, two-tailed) and category fluency ($r = .33, p = .126$ ns, two-tailed) tasks were positively associated with performance on the Eyes Test, the strength of association was weak and these findings were not significant. Therefore, these findings only partly support the hypothesis that there would be a significant relationship between performance on all measures of executive function and the Eyes Test.

Similarly, performance on the Eyes Test was also positively associated with performance on the Beck depression inventory (BDI-II) ($r = .29, p = .120$ ns) although the strength of association was weak and non significant. Interestingly, stroke participants' performance on the Eyes Test was found to be negatively related to age ($r = -.42, p = .02$, two-tailed), although was not significantly associated with years of education ($r = .01, p = 1.00$ ns, two-tailed) (see Appendix 13) or IQ ($r = .26, p = .234$ ns, two-tailed).

Table 26 also shows that, interestingly, performance on the Brixton Task was not significantly associated with either letter ($r = .20, p = .369$ ns, two-tailed) or category ($r = .20, p = .357$ ns, two-tailed) fluency. The fluency measures were however strongly and significantly associated with each other ($r = .724, p < .01$, two-tailed). Performance on the Brixton task was also found to be significantly related to age ($r = -.46, p < .01$, two-tailed), years of education ($r = .45, p < .01$, two-tailed) (see Appendix 13), and IQ ($r = .44, p < .05$, two-tailed).

It was also of interest that performance on the dysexecutive (DEX) questionnaire was not significantly associated with performances on the Brixton task ($r = .01, p = .945$ ns, two-tailed) or letter ($r = .18, p = .409$ ns, two-tailed) or category ($r = .60, p = .785$ ns, two-tailed) fluency tasks all of which are argued to measure executive function. It should also be noted that performance on the Eyes Test was negatively associated with performance on the DEX ($r = -.11, p = .548$ ns, two-tailed) although this finding was not significant.

3.4.2 Analysis of Covariance (ANCOVA)

It was hypothesised that executive function deficits would not fully account for impairments in ToM ability amongst stroke patients. Due to the associations found between stroke participants' performance on the theory of mind (ToM) Eyes Test, a measure of executive function (Brixton Task), depression and age, an analysis of covariance (ANCOVA) was conducted controlling for these factors.* The findings for the right and left-sided lesioned individuals are shown in Table 27. The same analyses were also run for the anterior and posterior lesion groups (Table 28).

* In psychopathology research, analysis of covariance (ANCOVA) is an approach commonly utilised to 'control for' group differences on potential covariates. However, Miller and Chapman (2001) describe the many difficulties and inappropriate uses of using ANCOVA in this way. With hindsight, it may have been more prudent to separate out these sources of variance by adopting a different experimental design. However, this was considered too impractical for the purposes of the present study, and was the main reason the author partialled out the variance by using ANCOVA. Readers are referred to Miller and Chapman (2001) for a fuller discussion of these difficulties and related issues.

Table 27. ANCOVA comparing right and left sided lesion and control groups performance on the Eyes Test controlling for age, depression and performance on the Brixton task.

Source	Type III Sum of Squares	df	F	Sig.	Partial Eta Squared
Corrected Model	619.651(a)	5	12.571	.001	.495
Intercept	967.229	1	98.113	.001	.605
age	95.522	1	9.689	.003	.131
Brixton (raw error score)	22.485	1	2.281	.136	.034
BDI	20.084	1	2.037	.158	.031
Lesion group	308.982	2	15.671	.001	.329
Error	630.935	64			
Total	16613.000	70			
Corrected Total	1250.586	69			

a. R Squared = .495 (Adjusted R Squared = .456)

As the results in Table 27 show, age is the only covariant significantly associated with performance on the Eyes Task. Including age, depression, and scores on Brixton dysexecutive functioning task did not notably alter the effect of lesion grouping (right versus left) upon performance on the Theory of Mind Eyes Test. The effect of lesion group is still significant $F(2, 64) = 15.67, p < .01$, representing an effect size (partial η^2) of .329. Thus nearly 33% of the variation in performance on the Eyes Test can be accounted for by lesion group.

Table 28. ANCOVA comparing anterior and posterior and control groups performance on the Eyes Test controlling for age, depression and performance on the Brixton task.

Source	Type III Sum of Squares	df	F	Sig.	Partial Eta Squared
Corrected Model	420.739(a)	5	6.490	.001	.336
Intercept	964.623	1	74.394	.001	.538
age	79.944	1	6.166	.016	.088
Brixton (raw error score)	29.500	1	2.275	.136	.034
BDI	19.016	1	1.467	.230	.022
Lesion group	110.070	2	4.244	.019	.117
Error	829.847	64			
Total	16613.000	70			
Corrected Total	1250.586	69			

a R Squared = .336 (Adjusted R Squared = .285)

Table 28 demonstrates that again age is the only covariant significantly associated with performance on the Eyes Task. Including age, depression, and scores on the Brixton dysexecutive functioning task did not notably alter the effect of lesion grouping (anterior vs posterior) upon performance on the ToM Eyes Test. The effect of lesion group remains significant. However, the interesting finding is that $F(2, 64) = 4.24$, $p < .05$ represented an effect size (partial η^2) of .117, indicating that only around 12% of the variation in performance on the Eyes Test can be accounted for by lesion group. Overall, these findings support the hypothesis that executive function deficits do not fully account for impairments in ToM ability, and demonstrate that the Right/Left hemisphere division can account for more of the variation in performance on the ToM Eyes Test than the Anterior/Posterior dimension.

CHAPTER FOUR: DISCUSSION

4.0 DISCUSSION

The Scottish Intercollegiate Guidelines Network (2002) report stroke as being the most frequent cause of severe disability in Scotland, and consequently, a substantial proportion of health and social care resources are being devoted to the immediate and continuing care of people who have suffered a stroke (Department of Health, 2001).

Although the consequences of stroke can vary significantly among individuals, the impact stroke can have on individuals' lives and those of their families is great. In addition to the more obvious changes in motor function, anxiety and depression commonly occur following stroke and have been recognised as having a detrimental effect on recovery and outcome (Robinson, 1998; Astrom et al., 1993). Cognitive and emotional deficits are also common following stroke and are factors that have been shown to constitute major obstacles to recovery and to achieving maximal quality of life (Riepe et al., 2004; Elinger et al., 2002; Bogousslavsky, 2003; McKinlay & Brooks, 1984). They can also disrupt processes central to social interaction, which can result in diminished psychosocial functioning (Hochstenbach et al., 1998; Rasquin et al., 2002). Owing to their often subtle nature, however, they commonly go unrecognised.

There is strong evidence that demonstrates stroke rehabilitation improves functional outcome and enhances quality of life, but rehabilitation research has tended to focus on physical or motor aspects of stroke. Relatively little attention has been paid to the emotional perception or social functioning problems which can occur in stroke patients. Consequently, a better understanding of these difficulties is required so that

early identification of problems can lead to enhanced care and treatment and adequate support for both individuals and their families. The main aim of this study was to investigate a specific element of social competence commonly referred to as Theory of Mind (ToM) in post-stroke individuals. ToM entails the ability to attribute mental states in order to explain and predict other people's behaviour and is often viewed as inherent to successful social functioning.

4.1 General Findings

In this study, 93% of stroke participants had suffered an ischaemic stroke, with the remaining 7% having experienced a haemorrhagic stroke. The presentations and recovery patterns of each can be qualitatively different and will be discussed in more detail in the methodological issues section to follow. Relatively equal numbers of males and females were represented in both the stroke and control groups. This was deemed important because, although not investigated in this study, there is evidence to suggest that sex differences exist between the emotional understanding abilities of males and females, with females tending to display significantly better emotional understanding than males (see Byrne, 1996).

4.1.1 Age, Years of Education and IQ

In terms of age, years of education and NART predicted IQ the stroke groups and control group were relatively well matched with no significant differences being found between the groups on any of these factors. It was noted however that the control group had slightly more years of education and higher mean IQ than stroke patients. This appears to be a common finding in brain injury research in general.

This may be due to sampling issues or may be linked to factors such as socioeconomic status, which is a factor commonly viewed as mediating the likelihood of stroke amongst others.

4.1.2 Depression

There was a surprisingly low frequency of depression amongst stroke patients in this study (7%), which is not in keeping with previous research findings that estimate the occurrence of depression as being between 25 to 50 percent in stroke survivors. (see Robinson, 1998). Similarly, Sinyor et al. (1987) reported prevalence rates for mild, moderate and severe depression as 17%, 23% and 9% respectively in a sample of patients admitted to a rehabilitation ward. Therefore, in relation to mood, the patients in this study were not representative of stroke survivors in general. A possible reason for this finding will be discussed later when considering the methodological issues concerning this current study.

4.1.3 Time Since Stroke

With respect to number of days that had passed between date of stroke and date of testing, the overall mean for stroke patients was 74.2 days (SD = 32.08). No significant difference in mean number of days since stroke between the right-sided lesion (RSL) group compared to the left-sided lesion group (LSL) was found, although the median number of days was notably lower in the RSL group (see Figure 1 in Results section). Therefore, it could be argued that any differences found on the measures used in this study between RSL and LSL groups were due to the differences in time since stroke. However, recovery from stroke is very dependent

on individual factors, including location and extent of lesion, therefore it is difficult to be sure what effect this finding may have had on performance on the various measures used in this study.

4.1.4 Location of Lesion

Using the classification system advocated by Bamford (1992) (see section 1.1.4 in Introduction section) total anterior circulation infarcts (TACI) were the most common presentation of stroke in this study, followed by lacunar infarcts (LACI). Following Burgess and Shallice (1997), patients were also classified as having either anterior or posterior lesions. Lesion evidence was based on medical interpretation of clinical radiological MRI or CT report and information documented in medical notes. However, there are a number of problems inherent to reliance on medical note entries and scan results in addition to the problems with classification systems themselves. These methodological issues are discussed in more detail in section 4.4.

4.2 Findings in Relation to Specific Hypotheses

4.2.1 Theory of Mind

4.2.1 (a) Right versus Left Stroke

The Eyes Test

It was hypothesised that individuals with right-hemisphere lesions would perform significantly worse on the Eyes Test, a task commonly believed to measure theory of mind (ToM), compared to individuals with left-hemisphere lesions and controls.

The results demonstrated that The RHL group's performance on the theory of mind Eyes Test was significantly poorer than both the LHL group and control group, whose performances did not differ significantly from each other. Results also showed that nearly 36% of the variance could be accounted for by lesion group. Thus, the results support this hypothesis, and are in keeping with those reported by Happe et al (1999). This finding is perhaps not surprising, however, considering that RHL individuals are known to show pragmatic and social difficulties and the large amount of evidence implicating right hemisphere damage in impairments of social awareness and behaviour and emotional perception (Carota et al., 2002; Zdzgaljardic et al., 2002; Borod et al., 1998). Nonetheless, it is interesting that Happe et al's (1999) findings have been replicated, despite using a different ToM measure in this study and suggest the right hemisphere as having an important role in supporting ToM ability. These findings also lend support to the fact that impairments in ToM can be acquired following stroke, similar to other forms of brain injury.

It was further hypothesised that there would be no significant differences between the groups' performance on the Eyes Control Task. This hypothesis was also supported, and in line with previous research findings (Baron-Cohen et al, 2001; Happe et al., 1999). There was, however, an apparent ceiling effect in performance on this task. This finding suggests that the task was in some way too easy and perhaps not suitable as a control task for the ToM Eyes Test. On the other hand, it does suggest that individuals were able to adequately see the task photographs, giving more confidence that the findings of the RHL groups poor performance on the ToM Eyes Test was unlikely to be due to visual acuity problems.

4.2.1 (b) Anterior versus Posterior Stroke

The Eyes Test

An additional hypothesis of this study in relation to the Eyes Test was that individual's with anterior lesions would perform significantly worse on this measure compared to individual's with posterior lesions and controls. However, the results did not support this hypothesis. Both stroke groups' (anterior and posterior) performed significantly worse than the control group, but did not differ significantly from each other. Although not significant, a quite unexpected finding was that the anterior lesion group actually performed marginally better than the posterior lesion group.

It was thought that damage to the anterior region of the brain would impede performance on this task because of research that has shown the frontal cortex to be involved in ToM abilities (Baron-Cohen et al., 1994) and shown activation during ToM tasks in imaging studies (Fletcher et al., 1995). One possible explanation for this unexpected finding could be lack of specificity of lesion site. Owing to the nature of stroke, it is possible that patients with anterior lesions also had damage to non-frontal areas of the brain which were not detected by brain scans. This problem is commonly seen in clinical practice. Alternatively, it is possible that the frontal lobes have a more vital role in ToM tasks that have a higher cognitive component. As outlined in section 2.3.2 of the method section, the Eyes Test is thought to tap the affective aspects of ToM ability (Baron-Cohen et al., 2001), which the frontal cortex is perhaps not vital for. This would fit with Premack and Woodruff's idea of ToM being a primitive ability and therefore supported by less evolutionary advanced

structures (i.e. more posterior subcortical structures). An alternative conclusion could be that the right hemisphere per se is more important in aiding performance on this task than the anterior region of the brain; that hemispheric location of lesion is more important than the anterior/posterior division.

It was also further hypothesised that there would be no significant differences between groups on the Eyes Control task. This hypothesis was supported, although similar to the findings in the right/left lesion and control groups performance on this task, there was an apparent ceiling effect with the implications being the same as previously discussed.

4.2.1 (c) Exploratory Findings

Although no specific predictions were made, this study posed the question: Is there a specific lesion site (e.g. right anterior or right posterior) that is more detrimental to performance on the ToM task than any other?

The results demonstrated that there were significant differences between the groups performance on the ToM Eyes Test. The right anterior lesion group was found to have performed the poorest ($n = 6$, $M = 9.50$, $SD = 2.74$) and differed significantly from the left anterior group ($n = 7$, $M = 16.00$, $SD = 1.83$) and control group ($n = 40$, $M = 16.42$, $SD = 3.37$), but did not differ significantly from either the right posterior ($n = 9$, $M = 10.44$, $SD = 4.95$) or left posterior ($n = 8$, $M = 14.62$, $SD = 3.74$) groups. The right posterior lesion group's performance differed only from

the control group's performance. No other significant differences between the groups were found.

It is interesting that the right anterior group did not differ significantly from the right posterior group. It has been asserted that the most common sites of cerebrovascular disease affecting emotion-related processing are the right hemisphere and frontal lobe (Zgaljardic et al 2002; Borod et al, 1992). In addition, current models of emotion and the brain emphasise a vital role for the posterior right hemisphere in the accurate perception of emotional stimuli such as emotional facial expression (Carota et al., 2002) Therefore, this finding is in keeping with previous research. It seems that areas in the right anterior and right posterior regions of the brain are in some way vital for successful performance on the ToM task used in this study.

The finding that the right anterior lesion group's performance did not differ significantly from the left posterior group's performance is interesting. This suggests two things. Firstly, it may be that this area plays a role in performance on the Eyes Test thus implicating the right frontal and right and left posterior regions of the brain. The interconnectivity within the brain would make this possible and would support the idea of a widespread neural circuit vital to ToM ability. Alternatively, it may be that power was not adequate to detect significant differences between the right anterior and left posterior groups due to the small sample sizes. Indeed, the mean scores appear to show a large difference between these two groups. If this is the case, then results would suggest that lesions to the right anterior region of the brain are perhaps the most detrimental to ToM ability with this group performing the

poorest. Although possible, the results of this study do not provide unequivocal support for this suggestion.

4.2.2 Executive Function

4.2.2 (a) Right versus Left Stroke

It was hypothesised that both stroke groups (right-sided lesion (RSL) and left-sided lesion (LSL)) would perform poorly on tasks of executive function compared to controls.

The Brixton Task

Results showed both the RSL and LSL groups to be significantly impaired on the Brixton task compared to controls, but as predicted, they did not differ significantly from each other. This result is also in keeping with previous findings showing executive dysfunction as being the most common presenting problem in neuropsychological practice following brain injury (e.g. stroke), irrespective of side of lesion (Stuss & Levine, 2002).

It was also of interest that, although not significant, the RSL group performed the poorest compared to the LSL group. Individuals with right hemisphere damage characteristically have difficulties in the area of visuoperceptual functioning (Hochstenbach et al., 1998) and therefore performance may have been affected by the visuoperceptual component of the Brixton task; the RSL group's difficulties may not have been entirely owing to problems in executive functioning. However, this

suggestion may have been more plausible if the RSL group had performed significantly worse than the LSL group, which was not the case. The finding that there were no significant differences between the stroke groups suggests the Brixton task and the Eyes Test are measuring different constructs, as would be expected, and further supports the results found on the Eyes Test; the RSL group were not performing poorly on the Eyes Test because of visuoperceptual problems. Furthermore, this finding also suggests it is less likely that visual neglect played a contributory role to the RSL poor performance on the Eyes Test.

Verbal Fluency

With regards to letter fluency, both the RSL and LSL groups' performances were found to differ significantly from the control group's performance, but not from each other. This finding supports the hypothesis that no differences would be found between the stroke groups' performances on measures of executive function. However, it was interesting to note that, whilst not significant, the LSL group's performance was better than the RSL group's performance on this task and actually fell within the low average range of normal performance (mean $t = 42$). This is in some way counter intuitive given that the left hemisphere is viewed as being dominant in language abilities (Lezak et al., 2004), which constitute a large part of this task. This finding, however, may be explained by the fact individual's with language difficulties in the LSL group did not perform this task ($n = 7$) and were therefore excluded from analysis. Because of this, this finding may not give an accurate reflection of the difficulties left hemisphere damaged individuals' may possibly have with this aspect of executive function (i.e mental flexibility).

Similar results were found for performances between the groups on the category fluency task, further supporting the hypothesis. Both stroke groups (RSL and LSL) were significantly impaired compared to controls, but did not differ significantly from each other. As before, the RSL group were more impaired than LSL group, who again performed at the very low end of the normal range. The explanation given above with regards to language ability would also account for this finding. However, it is also possible that the pattern of findings for both verbal fluency tasks can be explained by deficits in processing speed, which has been found to be significantly affected following right hemisphere damage (RHD) (Gerritsen et al., 2003; Rasquin et al., 2004a). Owing to verbal fluency being a timed task, reduced processing speed may have therefore affected the RSL group's performance. Overall, however, these findings suggest that executive functioning problems are common following stroke, irrespective of side of lesion.

4.2.2 (b) Anterior versus Posterior Stroke

It was hypothesised that the anterior lesion (AL) group would perform significantly worse on tasks of executive function compared to the posterior lesion (PL) group and controls.

Brixton Task

The results showed that, although the anterior group performed less well on the Brixton Task compared to the posterior group and controls, the only significant difference between the groups was between the performance of both stroke groups (anterior and posterior) and controls. The stroke groups did not significantly differ from each other. Therefore, this finding does not support the hypothesis.

It had been thought that that the anterior stroke group's performance on this task would differ significantly from the posterior stroke group's performance because of evidence that shows the frontal cortex as being important to executive functioning ability (Lezak et al., 2004). Therefore, one explanation for this finding could be that individual's in the AL group also had lesions to more posterior regions of the brain. The difficulties with lesion specificity were outlined in section 4.2.1(b). Alternatively, it may be that the frontal lobes are not the only vital region of the brain for successful performance on this task. Indeed, Phillips (1997) points out that there are many difficulties with tasks of executive function. They are often assumed to be tests of frontal lobe functioning, which she argues is misguided. Individuals with lesions that do not involve the frontal lobes have been found to perform poorly on tasks of executive function (Benton, 1991), and therefore cautions against the use of the term 'frontal tasks' because of this. Most authors agree that executive function consists of a number of interconnecting control processes, which are perhaps not solely dependent on the frontal lobes. Therefore this task may be tapping an aspect of executive functioning that is reliant on structures other than the frontal lobes. The above finding would support this view.

Verbal Fluency

With regards to letter fluency, the results indicated that there were no significant differences between the anterior lesion (AL) group and posterior lesion (PL) group, although both stroke groups preformed within the impaired range and significantly worse than controls. Therefore, these findings do not support the hypothesis.

Similar to above, it had been thought that performance on this executive function task would be reliant on intact frontal lobe functioning, largely owing to the large amount of evidence that suggests the neural substrates of executive processes lie in the frontal cortex (see Stuss & Benson, 1986). However, the difficulties with this view have been outlined above and may account for this finding. The problems with lesion specificity also remain. It is interesting, however, that similar to the results found on performance on the Brixton task, the AL group displayed the poorest performance. An alternative explanation for this finding could be that, owing to the small number in the anterior group ($n = 7$) compared to the posterior group ($n = 16$), power was not adequate to detect a significant difference. In view of all these factors, it is difficult to be clear why this result was found.

In terms of performance on the category fluency task, the results showed a significant difference between both stroke groups (anterior and posterior) and controls. The stroke groups, however, did not differ significantly from each other. Thus, this finding does not support the hypothesis.

In contrast to the letter fluency findings, the posterior group performed the poorest on the category fluency task compared to the anterior lesion group, and was the only group found to be within the impaired range. This finding is contrary to what was expected, with possible explanations being the same as outlined above (e.g. lesion specificity and problems with viewing executive function tasks as tests of frontal lobe functioning). It is interesting, however, that despite the non significant results between the stroke groups, there seemed to be something about anterior lesions that appeared to be more detrimental to letter fluency performance, whereas category fluency performance appeared to be more sensitive to posterior lesions. There is the view that greater contribution of the frontal lobes is required for letter fluency performance, but not category fluency, with patients with frontal lesions being found to be impaired on letter, but not category, fluency (see Henry & Crawford, 2004). The findings of this study are tending towards supporting this view, but are not conclusive.

4.2.2 (c) Dysexecutive Questionnaire (DEX)

Right versus Left Stroke

It was hypothesised that individuals in the right-sided lesion (RSL) group would rate themselves as having fewer dysexecutive difficulties compared to how individuals in the left-sided lesion (LSL) group would rate themselves. It was further hypothesised independent raters would score individuals in the RSL group as having more dysexecutive problems than LSL individuals, thus indicating RSL individuals as having less awareness of difficulties.

The results showed that the RSL group rated themselves very slightly higher than the LSL group although this difference was not significant. Thus, the first hypothesis is not supported. Independent raters were found to score patients in the RSL group more highly on the DEX compared to the LSL group. This finding therefore supports the latter hypothesis. Compared to the LSL group, the range of scores observed in the RSL group and the independent ratings of this group suggest that the RSL group had less awareness of deficits, which is in keeping with previous research findings showing anosognosia (lack of awareness) to be more commonly associated with right-sided stroke (Giacino et al., 1998; Starkstein et al., 1992; Hartmann – Maeir et al., 2002). Results also showed the LSL group rated themselves as having greater dysexecutive difficulties than the independent raters believed them to have, which raises questions about the reliability of the scores given by independent raters. This issue will be discussed further when considering other methodological issues (section 4.4), but highlights these findings should be viewed with caution.

Anterior versus Posterior Stroke

It was hypothesised that individuals with anterior lesions (AL) would score themselves as having less dysexecutive problems compared to the extent of dysexecutive difficulties the posterior lesion (PL) group considered themselves to have. It was further hypothesised that the AL group would be rated as having greater dysexecutive difficulties than the PL group by independent raters, thus indicating AL individuals to have less awareness of difficulties.

The results showed that contrary to what was expected the AL group rated themselves as having more difficulties than the posterior group believed themselves to have, although the difference between groups was not significant. Therefore, this hypothesis has not been supported. However, as predicted, the independent raters scored individuals in the AL groups as having more dysexecutive problems compared to the PL group, which is in keeping with previous research (Wilson et al., 1996). An intriguing finding was that the AL group also rated themselves as having more difficulties than the independent raters considered them to have. Therefore, this finding adds to the methodological concerns raised previously regarding the reliability of independent raters observations of patients and, similarly, should be treated with caution.

4.3 Theory of Mind and Executive Function

4.3.1 Relationships Amongst Variables

Theory of Mind Eyes Test

It was hypothesised that amongst stroke patients there would be a significant and positive relationship between measures of executive function and theory of mind (TOM). This hypothesis was related to the argument that ToM ability is mediated by the frontal lobes (Baron-Cohen et al., 1994; Fletcher et al., 1995) and executive functions (Frye et al., 1995; Ozonoff et al., 1995).

The results showed that performance on the ToM Eyes Test was moderately and positively related to performance on the Brixton Task, which is believed to measure executive function. However, Verbal Fluency tasks (letter and category) were not significantly associated with the Eyes Test although the direction of association was positive. Therefore, this hypothesis was only partly supported.

It is perhaps not surprising that a positive association was found amongst all of these tasks, albeit to varying degrees. As Fine et al. (2001) highlight, most tests used to assess cognitive function are not pure; they inherently assess other aspects of functioning. However, The Eyes Test and Brixton task were perhaps significantly related because both conceivably have a visual component. That verbal fluency was not significantly associated with the Eyes Test is, with hindsight, not surprising. The Eyes Test is predominantly a non-verbal task, whereas the verbal fluency task is heavily dependent on verbal ability. Overall, these findings suggest that performance on the Eyes Test is dependent, in part, on some aspect of executive functioning, with some suggestion that the Eyes Test is perhaps measuring something other than executive function per se.

The results also revealed The Eyes Test to be negatively associated with age. This is not in keeping with previous research (Happe et al., 1998), which showed older adults to perform significantly better on a ToM task compared to younger controls. However, more recent studies have also failed to replicate Happe et al's (1998) findings (Sullivan & Ruffman, 2004; Maylor et al., 2002). One explanation for this contradiction may be due to different ToM tasks being used in each study. Happe et

al. (1998) used a ToM task with a greater verbal component, which may be more resistant to aging effects. The ToM Eyes Test used in this study relies more on non-verbal or visual skills. Therefore, this finding may be related to visual acuity, which is known to decline with age, although the results of the Eyes control task would not support this suggestion.

There was also a peculiarly low association between the Eyes Test and years of education (see appendix 13). The results suggested these variables were completely unrelated. Similarly, results also revealed the Eyes Test not to be significantly associated with IQ, which is in keeping with the findings of Baron-Cohen et al. (2001). Together, these findings suggest that ToM ability is independent of general intelligence and lends support to the idea that the Eyes Test is tapping the affective aspect of ToM ability, which has been argued as being more primitive in nature and not heavily reliant on cognitive ability (Premack & Woodruff, 1978; Baron-Cohen et al., 1992)

Executive Function

The results also showed that the Brixton task was not correlated with Verbal Fluency, which are both believed to be measures of executive function. However, in retrospect, this finding is perhaps not unexpected. It is highly likely that both tests are measuring different aspects of executive function (as outlined in section 4.2.2(b)), although there is also the possibility that some other factor (cognitive or otherwise) was affecting performance on one measure and not others. The Brixton task was also found to be significantly and negatively correlated with age, which is in

keeping with previous research findings (Burgess & Shallice, 1997). Also, the Brixton task was significantly and positively related to years of education, which again is in keeping with previous findings (Burgess & Shallice, 1997).

Interestingly, the dysexecutive questionnaire (DEX) was not found to significantly correlate with performance on the Brixton or Verbal Fluency tasks, which are all argued to be measures of executive function. As outlined above, it is possible that each task is measuring different aspects of executive function, but given the methodological issues concerning the DEX highlighted in section 4.2.2 (c), it seems more plausible that this finding is an artefact of this study.

Theory of Mind and Executive Function

It was further hypothesised that deficits in executive function would not fully account for impairments in ToM ability amongst stroke patients.

Comparing the performance of right- and left-sided stroke groups and controls, the results showed that age was the only covariant significantly associated with performance on the Eyes Test, although depression and performance on the Brixton task were also positively associated with performance on the Eyes Test. Controlling for these covariants did not alter the significant difference between lesion groups. The differences between the groups remained significant with hemispheric location of lesion accounting for 33% of the variance.

Similarly, in the anterior/posterior comparison, age was again the only covariant significantly associated with performance in the Eyes Test. Controlling again for age, depression and performance on the Brixton task revealed that the effect of lesion group remained significant. However, only 12 % of the variation in performance could be accounted for by lesion site.

Overall, this hypothesis has been supported. However, it seems that right-sided lesions per se are more detrimental to performance on the ToM task used in this study. This conclusion would be in keeping with previous research findings (Happe et al., 1999), which showed the right hemisphere to play a particular role in ToM ability.

4.4 Methodological Considerations

Although the results of this study lend support to the view that acquired impairments following stroke are the result of damage to the right hemisphere, there are a number of methodological considerations and criticisms that should be considered before drawing any firm conclusions.

4.4.1 Stroke Participants

In relation to stroke participants in this study, 93% of stroke participants had suffered an ischaemic stroke, with the remaining 7% having experienced a haemorrhagic stroke. Although qualitatively different, it is thought unlikely that the inclusion of haemorrhagic strokes ($n = 2$; one in RSL group and one in LSL group) would have significantly altered results. On the other hand, a strength of this study is that it did

not comprise a number of differing aetiologies, which is a criticism of many of the studies conducted within the brain injury field of research.

4.4.2 Lesion Specificity

There are also issues concerning lesion specificity following stroke, which are common to most brain injured population studies. The very nature of stroke means that often individuals may have experienced asymptomatic strokes or transient ischaemic attacks TIAs, which have been shown to result in infarction of brain tissue (Bogousslavsky, et al., 1998). It is therefore possible that some individuals in this study had damage to other areas of the brain that did not show up on scans, similar to the findings following traumatic brain injury (TBI).

Similarly, the brain scans had in all cases been undertaken very soon following stroke, presumably to establish cause of symptomatology and to guide clinical management. As Happe et al (1999) highlight, the final pattern of tissue damage may not be revealed by scans at this early stage owing to secondary physiological processes, which could result in either further damage or recovery of brain tissue being possible. Therefore, lesion information should be viewed with caution. However, it is difficult to know the best way to overcome this problem, which is not uncommon in other areas of neuropsychological research.

4.4.3 Time Since Stroke

A related issue concerns the length of time that had passed between the occurrence of stroke and date of testing. It could be argued that the individuals in this study were still in the early stages of recovery, with mean number of days since stroke being 74.2 days (see section 4.1.3). It is well known that spontaneous recovery can continue for a considerable period of time following stroke. However, the rationale for testing stroke participants in the post-acute stage of recovery was primarily because, in clinical rehabilitation settings, this is often the time when emotional or behavioural difficulties become apparent. Such difficulties are also known to affect rehabilitation progress (Hartmann-Maeir et al., 2002). Whether the difficulties found in this study are longstanding, or not, would require further research. However, there is some evidence to suggest that, for some individuals, these difficulties will remain (Hochstenbach et al., 2003; Rasquin et al., 2004a; Happe et al., 1999), and therefore early identification was considered important.

4.4.4 Depression

As outlined in section 4.1.2 there was a surprisingly low incidence of depression found in this study. It may be that this was an accurate reflection of depression rates in this particular sample. However, there is an alternative explanation. Information regarding current treatment of mood problems was not gathered from patients' medical notes. It is possible that a percentage of stroke patients were receiving pharmacological treatment for mood disorders, which would have masked the true prevalence of depression within this sample. This explanation seems the most likely.

With hindsight, it would have been prudent to have sought this information prior to testing and is a criticism of this study.

4.4.5 Measures

It is also possible that the findings in this study are the result of other factors (cognitive or otherwise) affecting performance on the tasks used in this study, notwithstanding the criticisms of the individual measures themselves. Multiple cognitive deficits are not uncommon following stroke (Rasquin et al., 2004), with mental speed of processing being reported as the most frequently disturbed cognitive function (Rasquin et al., 2004; Gerritsen et al., 2003). However, it was thought unlikely that reduced processing speed significantly affected performance because there were no time restrictions for completing the measures used in this study, and the pace for completing these was set largely by the participants themselves. The only exception to this was the Verbal Fluency tasks, with this issue already having been discussed previously (see section 4.2.2a).

Variations in presentation of cognitive deficits are also seen depending on which hemisphere of the brain has been damaged. The most obvious cognitive disorders for those individuals with right-sided damage involve visuospatial abilities and gestalt-type formation (Lezak et al., 2004). Left-sided visual neglect, often viewed as being characteristic of stroke, is also common (Heir et al., 1983). It could be assumed, therefore, owing to the visual nature of the Eyes Test and the Brixton executive function task, that the findings in this study may be the result of perceptual problems or neglect. This issue was briefly alluded to in section 4.3.1 where it was

suggested that this was not the case. Further support for this conclusion comes from the finding stroke participants were able to perform the Eyes Control Test well. Indeed, they performed at ceiling on this task.

The design format of the Eyes and Eyes Control Tests response sheet also allowed for the detection of neglect. It would have been apparent if individuals were not attending to one side of the picture because their responses would have been limited to b and d, or a and c on the response sheet (see appendices 2 and 3). However, this was not the case. It may be that the minor modification made to the administration of these tasks compensated for this, if indeed neglect was present (see section 2.3.2 in the Method section).

A further methodological issue concerns the Eyes Test itself. It has been argued to tap the affective component of ToM because it involves a basic emotion recognition element (Baron-Cohen et al., 2001). It may be that the Eyes Test is actually measuring emotion recognition and not the ToM construct. Therefore, whether a theory of mind account is the correct one for the RSL group's poor performance on the Eyes Test depends on what the Eyes Test is actually measuring. It is difficult to draw any firm conclusions about the validity of the Eyes Test because a measure of basic emotion recognition was not used to control for this. With hindsight this would have been sensible, and not doing so could be considered a criticism of this study.

There were also methodological concerns raised by the patterns of findings on the DEX questionnaire, particularly in relation to the ratings of patients by observers.

These were briefly highlighted in section 4.2.2(c). The results found may have been due to the fact not all stroke participants were rated by the same person, which included members of both the nursing and therapy teams. Looking at the data qualitatively, it seemed that therapy staff appeared to demonstrate a better understanding of the patients' difficulties. It may be that nursing staff were so used to seeing these types of deficits they underestimated their significance. In hindsight, it may have proved more prudent to have involved the patient's spouse or close relative, who may have been in a better position to comment on changes in behaviour. Patients' own ratings on this questionnaire may have been influenced by negative feelings about themselves. Many felt they were making slow progress in therapy. In addition, the DEX does not stipulate a timeframe for individuals to consider changes in behaviour within. It is possible that some individuals were referring to frequencies of dysexecutive type difficulties that may have been present prior to having had a stroke.

4.5 Recommendations for Clinical Practice

It is difficult to make firm recommendations for future clinical practice given the methodological issues outlined above. However, the findings of this study suggest there may be scope for improvement.

At present, individuals who have been admitted to stroke rehabilitation wards are screened for mood disorders, such as depression, which commonly occur following stroke. However, this practice remains variable despite recommendations (SIGN, 2002). In addition to mood disorders, the results of this study suggest that

individuals who have experienced right-hemisphere stroke may be particularly susceptible to deficits in an aspect of social cognition commonly referred to as theory of mind (ToM). Impaired ability to attribute mental states to others can interfere with how individuals use information conveyed through social interaction and can, in turn, affect psychosocial functioning, disrupt interpersonal relationships, and lead to reduced quality of life. It also has implications for rehabilitation and relevance for relatives, carers and other professionals.

In view of these findings, it seems there may be merit in screening for these types of social functioning disorders as part of routine assessment, and as Carota et al. (2002) suggested, including social-related measures when assessing rehabilitation progress and overall outcome following stroke. The Eyes Test is a quick and simple measure to administer and score, and is relatively stress free for patients to complete. It may be that using the Eyes Test, or similar, as a screening measure for these types of difficulties would detect the often subtle deficits in this area of functioning. Information gained through the use of such measures could be used to positively re-frame problems as goals for rehabilitation. It is unclear at present however whether remediation of this deficit is possible, but feedback and discussion with the patient and significant others may highlight approaches that could be used as compensatory strategies, such as conveying meaning or intentions in written form.

Clinical experience has shown that by providing a cognitive or psychological explanation for observed behaviours can be extremely helpful for patients, families and other professionals, even if it only serves to increase understanding of the

individual and their experience. This allows an individual to adapt their style of approach to meet the needs of the patient and can dispel any misunderstanding about the motivations behind challenging behaviours. Furthermore, increased understanding of the nature of any impairment in social functioning is central to improved clinical management and rehabilitation.

4.6 Conclusions and Future Research

There is a wide range of behavioural manifestations of frontal lobe and right hemisphere dysfunction, and theory of mind (ToM) impairment clearly cannot account for all of these, nor is it likely to be responsible for all reported difficulties in social cognition. However, despite the methodological issues highlighted in section 4.4.5, the findings of this study do appear to suggest that right hemisphere damage following stroke is particularly detrimental to an aspect of social cognition commonly referred to as ToM.

The findings of this study also showed a high incidence of executive dysfunction, irrespective of side of lesion, but deficits in this area of cognitive functioning did not appear to fully account for the impairments seen in understanding pictures that required the attribution of thoughts and feelings to others. This suggests that the ability being tapped by the Eyes Test, commonly believed to be ToM, is in some way separable from other areas of cognitive functioning and can be selectively impaired following stroke. These findings, however, do not allow for the conclusion that

damage elsewhere in the brain cannot impair theory of mind ability, or that some other factor, cognitive or otherwise, may have resulted in these findings.

There is scope, therefore, for further research in this area. Firstly, a replication of this study including a measure of emotion recognition and an additional measure of ToM may elucidate whether the Eyes Test is indeed a valid measure of ToM ability or is simply a task of emotion recognition. Similarly, it would be of interest to include a measure of visual neglect to clarify whether deficits in this area of functioning can account for the poor performances on the ToM task used in this study.

It was highlighted in section 4.4.5 that the Eyes Test has limitations. One of the main criticisms that could be directed at this task is that it is perhaps not truly representative of the different kinds of information conveyed through social interactions in real-life (e.g. gestures, verbal cues, prosody, and context). The Eyes Test requires individuals to make judgments about another's mental states, desires or beliefs based on viewing static pictures thereby excluding some of the rich contextual information commonly present in normal social situations. It is difficult therefore to delineate exactly which aspect of ToM is responsible for the poor performance on the ToM Eyes Test. Further research in this area should aim to establish whether deficits in ToM are due to difficulties with specific aspects of ToM ability such as perspective-taking, emotion recognition, or difficulties with facial recognition per se. It may be of interest to investigate these issues through the use of

videoed ToM scenarios, which would provide verbal and gesture cues, as well as context.

It was also highlighted in section 1.4.1 that the construct of empathy is also conceivably linked to ToM because both require the ability to differentiate between the self and others (Visser-Kaiser, 2002). Individuals with brain injury are also known to display deficits in their ability to empathise with others (Grattan & Eslinger, 1989). Consequently, it would be of interest to investigate the relationships amongst these constructs and their particular contributions to successful social functioning. Therefore, further studies that inter-relate perception of emotion, theory of mind capabilities, and empathy in stroke patients may be warranted.

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APPENDICES

APPENDIX 1 – NATIONAL ADULT READING TEST (NART)

National Adult Reading Test (NART)

SECOND EDITION

Word Card

Hazel E. Nelson

CHORD

ACHE

DEPOT

AISLE

BOUQUET

PSALM

CAPON

DENY

NAUSEA

DEBT

COURTEOUS

RAREFY

EQUIVOCAL

NAIVE

CATACOMB

GAOLED

THYME

HEIR

RADIX

ASSIGNATE

HIATUS

SUBTLE

PROCREATE

GIST

GOUGE

SUPERFLUOUS

SIMILE

BANAL

QUADRUPED

CELLIST

FACADE

ZEALOT

DRACHM

AEON

PLACEBO

ABSTEMIOUS

DETENTE

IDYLL

PUERPERAL

AVER

GAUCHE

TOPIARY

LEVIATHAN

BEATIFY

PRELATE

SIDEREAL

DEMESNE

SYNCOPE

LABILE

CAMPANILE



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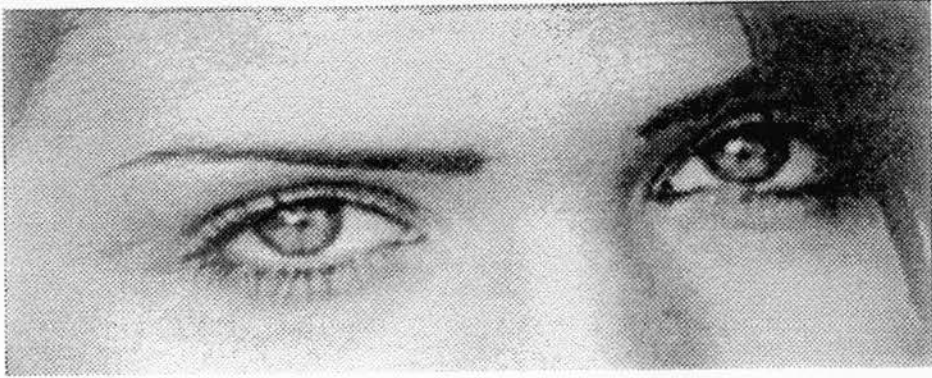
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**APPENDIX 2 – EXAMPLE OF ITEM FROM THE EYES TEST AND
RESPONSE SHEET**

joking

flustered



desire

convinced

Eyes Test

List of target mental state terms for each item (in italics) and their distractors

practice	jealous	<i>panicked</i>	arrogant	hateful
1	<i>playful</i>	comforting	irritated	bored
2	terrified	<i>upset</i>	arrogant	annoyed
3	joking	flustered	<i>desire</i>	convinced
4	joking	<i>insisting</i>	amused	relaxed
5	aghast	<i>fantasising</i>	impatient	alarmed
6	<i>despondent</i>	relieved	shy	excited
7	annoyed	hostile	horrified	<i>preoccupied</i>
8	<i>contemplative</i>	flustered	encouraging	amused
9	irritated	<i>thoughtful</i>	encouraging	sympathetic
10	dominant	<i>friendly</i>	guilty	horrified
11	<i>preoccupied</i>	grateful	insisting	imploring
12	contented	apologetic	<i>defiant</i>	curious
13	<i>pensive</i>	irritated	excited	hostile
14	panicked	incredulous	despondent	<i>interested</i>
15	alarmed	shy	<i>hostile</i>	anxious
16	joking	<i>cautious</i>	arrogant	reassuring
17	<i>interested</i>	joking	affectionate	contented
18	impatient	aghast	irritated	<i>reflective</i>
19	grateful	<i>flirtatious</i>	hostile	disappointed
20	ashamed	<i>confident</i>	joking	dispirited
21	<i>serious</i>	ashamed	bewildered	alarmed
22	embarrassed	guilty	fantasising	<i>concerned</i>
23	aghast	baffled	<i>distrustful</i>	terrified
24	puzzled	<i>nervous</i>	insisting	contemplative
25	ashamed	nervous	<i>suspicious</i>	indecisive

APPENDIX 3 – EYES CONTROL TASK RESPONSE SHEET

Answers are in bold italics

Stimulus	A	B	C	D
Practice	<i>Male 50-60</i>	Female 50-60	Male 40-50	Male 30-40
1	Female 40-50	Male 40-50	Female 50-60	<i>Male 50-60</i>
2	Female 45-55	Male 25-30	Female 35-40	<i>Female 25-30</i>
3	Male 20-25	<i>Male 30-40</i>	Male 45-50	Female 40-50
4	Female 25-35	<i>Male 30-35</i>	Male 40-45	Male 45-50
5	<i>Male 20-30</i>	Male 35-40	Male 30-35	Male 50-60
6	Male 35-45	Female 35-40	Male 30-35	<i>Female 25-30</i>
7	Female 45-50	<i>Male 35-45</i>	Male 25-30	Male 50-60
8	Female 40-50	<i>Male 25-35</i>	Female 25-30	Male 40-45
9	Male 40-50	Male 20-30	<i>Male 30-40</i>	Female 25-30
10	Female 40-50	Female 30-40	Male 25-35	<i>Female 25-30</i>
11	Male 40-50	<i>Male 25-35</i>	Male 35-40	Male 20-25
12	Female 35-40	<i>Female 25-30</i>	Male 20-30	Male 25-35
13	<i>Female 20-25</i>	Female 35-40	Male 30-40	Female 30-35
14	Male 35-45	Male 20-25	<i>Male 25-35</i>	Female 25-35
15	Male 25-35	<i>Female 25-30</i>	Female 35-45	Female 30-35
16	Female 35-45	Male 20-25	Male 25-35	<i>Female 25-35</i>
17	Male 35-45	<i>Male 20-30</i>	Female 30-40	Male 45-55
18	<i>Female 25-35</i>	Male 20-30	Female 20-25	Female 35-45
19	Male 50-60	Male 70-80	Male 45-50	<i>Male 60-70</i>
20	Female 40-45	Female 30-35	<i>Female 25-30</i>	Female 35-40
21	Female 40-50	<i>Female 25-30</i>	Female 35-40	Male 20-30
22	Male 20-30	Female 30-40	<i>Female 25-30</i>	Female 40-45
23	<i>Male 60-70</i>	Female 60-70	Male 70-80	Male 45-55
24	Female 45-50	<i>Female 25-30</i>	Female 40-45	Female 20-25
25	Male 30-40	<i>Female 30-35</i>	Female 40-50	Female 20-30

APPENDIX 4 – VERBAL FLUENCY (FAS) RESPONSE SHEET

CONTROLLED ORAL WORD ASSOCIATION TEST

(BENTON & HAMSHER 1976)

1. Give me the names of as many animals/occupations as you can think of.
2. I am going to give you a letter and I would like you to tell me as many words as you can think of that begin with that letter excluding proper nouns (i.e. names), numbers and the same word with a different suffix (i.e. all, always, altogether, e.t.c.). The first letter is ~~Q~~
F. The second letter is ~~W~~
A. The third letter is ~~W~~
S.

Time (Secs)	Animals/ Occupations	Q F	W A	W S
0 – 15				
15 – 30				
30 – 45				
45 – 60				
Totals				

Total:
Adjusted Score:
Percentile Range:
Classification:

APPENDIX 5 – THE BRIXTON TEST RESPONSE SHEET

The Brixton Spatial Anticipation Test

- 'There are many pages here which all have the same basic design on them. There are always ten positions, and one of them is always coloured blue' [point to filled circle on page one]. 'However the coloured one moves around according to various patterns that come and go without warning. These numbers [point to numbers underneath the circles] are just here to refer to the position – there is nothing complicated or mathematical about this test'.
- 'Now, as I turn the pages over, your job is to pick up on the pattern as best you can, and point to where you think the blue one is going to be on the next page. It's not guess-work – you can work it out. For instance, imagine the blue one was here [point to position 6], and then when I turn the page it goes to 7, and then to 8, then to 9 – you might reasonably expect it next to go to 10'.
- 'From time to time the pattern changes without warning, and then it is your job to pick up on the new pattern as best you can. Do you understand?'
- Give further assistance if necessary
- 'Obviously the first time you have nothing to go on, so your first answer will have to be a guess – have a guess as to where the blue one will be next'

Item/ page	Correct answer	Subject's response	Correct/ incorrect
1	any		
2	3		<input type="checkbox"/>
3	4		<input type="checkbox"/>
4	5		<input type="checkbox"/>
5	6		<input type="checkbox"/>
6*	7		<input type="checkbox"/>
7	4		<input type="checkbox"/>
8	3		<input type="checkbox"/>
9	2		<input type="checkbox"/>
10	1		<input type="checkbox"/>
11	10		<input type="checkbox"/>
12*	9		<input type="checkbox"/>
13	10		<input type="checkbox"/>
14	5		<input type="checkbox"/>
15	10		<input type="checkbox"/>
16	5		<input type="checkbox"/>
17	10		<input type="checkbox"/>
18	5		<input type="checkbox"/>
19*	10		<input type="checkbox"/>
20	7		<input type="checkbox"/>
21	8		<input type="checkbox"/>
22	9		<input type="checkbox"/>
23	10		<input type="checkbox"/>
24	1		<input type="checkbox"/>
25	2		<input type="checkbox"/>
26*	3		<input type="checkbox"/>

Item/ page	Correct answer	Subject's response	Correct/ incorrect
29*	8		<input type="checkbox"/>
30	1		<input type="checkbox"/>
31	2		<input type="checkbox"/>
32	3		<input type="checkbox"/>
33	4		<input type="checkbox"/>
34*	5		<input type="checkbox"/>
35	4		<input type="checkbox"/>
36	10		<input type="checkbox"/>
37	4		<input type="checkbox"/>
38	10		<input type="checkbox"/>
39	4		<input type="checkbox"/>
40	10		<input type="checkbox"/>
41*	4		<input type="checkbox"/>
42	9		<input type="checkbox"/>
43	9		<input type="checkbox"/>
44	9		<input type="checkbox"/>
45	9		<input type="checkbox"/>
46	9		<input type="checkbox"/>
47	9		<input type="checkbox"/>
48*	9		<input type="checkbox"/>
49	9		<input type="checkbox"/>
50	8		<input type="checkbox"/>
51	9		<input type="checkbox"/>
52	8		<input type="checkbox"/>
53	9		<input type="checkbox"/>
54	8		<input type="checkbox"/>
55	9		<input type="checkbox"/>

Table D

Raw score	Scaled score	Classification
0-7	10	Very superior
8	9	Superior
9-10	8	Good
11-13	7	High average
14-17	6	Average
18-20	5	Moderate ave.
21-23	4	Low average
24-25	3	Poor
26-31	2	Abnormal
>31	1	Impaired

Total number of errors
(raw score)

Scaled score

APPENDIX 6 – EXAMPLE OF DEX QUESTIONNAIRE
(SELF-RATING)

Dex Questionnaire Self-rating

This questionnaire looks at some of the difficulties that people sometimes experience. We would like you to read the following statements, and rate them on a five-point scale according to your own experience:

Subject's name _____

Date _____

- 1 I have problems understanding what other people mean unless they keep things simple and straightforward
☐0 ☐1 ☐2 ☐3 ☐4
Never Occasionally Sometimes Fairly often Very often
- 2 I act without thinking, doing the first thing that comes to mind
☐0 ☐1 ☐2 ☐3 ☐4
Never Occasionally Sometimes Fairly often Very often
- 3 I sometimes talk about events or details that never actually happened, but I believe did happen
☐0 ☐1 ☐2 ☐3 ☐4
Never Occasionally Sometimes Fairly often Very often
- 4 I have difficulty thinking ahead or planning for the future
☐0 ☐1 ☐2 ☐3 ☐4
Never Occasionally Sometimes Fairly often Very often
- 5 I sometimes get over-excited about things and can be a bit 'over the top' at these times
☐0 ☐1 ☐2 ☐3 ☐4
Never Occasionally Sometimes Fairly often Very often
- 6 I get events mixed up with each other, and get confused about the correct order of events
☐0 ☐1 ☐2 ☐3 ☐4
Never Occasionally Sometimes Fairly often Very often
- 7 I have difficulty realizing the extent of my problems and am unrealistic about the future
☐0 ☐1 ☐2 ☐3 ☐4
Never Occasionally Sometimes Fairly often Very often
- 8 I am lethargic, or unenthusiastic about things
☐0 ☐1 ☐2 ☐3 ☐4
Never Occasionally Sometimes Fairly often Very often
- 9 I do or say embarrassing things when in the company of others
☐0 ☐1 ☐2 ☐3 ☐4
Never Occasionally Sometimes Fairly often Very often
- 10 I really want to do something one minute, but couldn't care less about it the next
☐0 ☐1 ☐2 ☐3 ☐4
Never Occasionally Sometimes Fairly often Very often

- 11 I have difficulty showing emotion
☐0 ☐1 ☐2 ☐3 ☐4
Never Occasionally Sometimes Fairly often Very often
- 12 I lose my temper at the slightest thing
☐0 ☐1 ☐2 ☐3 ☐4
Never Occasionally Sometimes Fairly often Very often
- 13 I am unconcerned about how I should behave in certain situations
☐0 ☐1 ☐2 ☐3 ☐4
Never Occasionally Sometimes Fairly often Very often
- 14 I find it hard to stop repeating saying or doing things once I've started
☐0 ☐1 ☐2 ☐3 ☐4
Never Occasionally Sometimes Fairly often Very often
- 15 I tend to be very restless, and 'can't sit still' for any length of time
☐0 ☐1 ☐2 ☐3 ☐4
Never Occasionally Sometimes Fairly often Very often
- 16 I find it difficult to stop myself from doing something even if I know I shouldn't
☐0 ☐1 ☐2 ☐3 ☐4
Never Occasionally Sometimes Fairly often Very often
- 17 I will say one thing, but will do something different
☐0 ☐1 ☐2 ☐3 ☐4
Never Occasionally Sometimes Fairly often Very often
- 18 I find it difficult to keep my mind on something, and am easily distracted
☐0 ☐1 ☐2 ☐3 ☐4
Never Occasionally Sometimes Fairly often Very often
- 19 I have trouble making decisions, or deciding what I want to do
☐0 ☐1 ☐2 ☐3 ☐4
Never Occasionally Sometimes Fairly often Very often
- 20 I am unaware of, or unconcerned about, how others feel about my behaviour
☐0 ☐1 ☐2 ☐3 ☐4
Never Occasionally Sometimes Fairly often Very often

APPENDIX 7 – EXAMPLE OF DEX QUESTIONNAIRE
(INDEPENDENT RATER)

Dex Questionnaire

Independent rater

This questionnaire looks at some of the difficulties that people sometimes experience. We would like you to read the following statements, and rate them on a five-point scale according to your experience of _____ [the subject]:

- 1 Has problems understanding what other people mean unless they keep things simple and straightforward
☐0 ☐1 ☐2 ☐3 ☐4
 Never Occasionally Sometimes Fairly often Very often
- 2 Acts without thinking, doing the first thing that comes to mind
☐0 ☐1 ☐2 ☐3 ☐4
 Never Occasionally Sometimes Fairly often Very often
- 3 Sometimes talks about events or details that never actually happened, but s/he believes did happen
☐0 ☐1 ☐2 ☐3 ☐4
 Never Occasionally Sometimes Fairly often Very often
- 4 Has difficulty thinking ahead or planning for the future
☐0 ☐1 ☐2 ☐3 ☐4
 Never Occasionally Sometimes Fairly often Very often
- 5 Sometimes gets over-excited about things and can be a bit 'over the top' at these times
☐0 ☐1 ☐2 ☐3 ☐4
 Never Occasionally Sometimes Fairly often Very often
- 6 Gets events mixed up with each other, and gets confused about the correct order of events
☐0 ☐1 ☐2 ☐3 ☐4
 Never Occasionally Sometimes Fairly often Very often
- 7 Has difficulty realizing the extent of his/her problems and is unrealistic about the future
☐0 ☐1 ☐2 ☐3 ☐4
 Never Occasionally Sometimes Fairly often Very often
- 8 Seems lethargic, or unenthusiastic about things
☐0 ☐1 ☐2 ☐3 ☐4
 Never Occasionally Sometimes Fairly often Very often
- 9 Does or says embarrassing things when in the company of others
☐0 ☐1 ☐2 ☐3 ☐4
 Never Occasionally Sometimes Fairly often Very often
- 10 Really wants to do something one minute, but couldn't care less about it the next
☐0 ☐1 ☐2 ☐3 ☐4
 Never Occasionally Sometimes Fairly often Very often

Subject's name _____

Date of rating _____

Rater's name _____

Relationship to
subject _____

- 11 Has difficulty showing emotion
☐0 ☐1 ☐2 ☐3 ☐4
 Never Occasionally Sometimes Fairly often Very often
- 12 Loses his/her temper at the slightest thing
☐0 ☐1 ☐2 ☐3 ☐4
 Never Occasionally Sometimes Fairly often Very often
- 13 Seems unconcerned about how s/he should behave in certain situations
☐0 ☐1 ☐2 ☐3 ☐4
 Never Occasionally Sometimes Fairly often Very often
- 14 Finds it hard to stop repeating saying or doing things once started
☐0 ☐1 ☐2 ☐3 ☐4
 Never Occasionally Sometimes Fairly often Very often
- 15 Tends to be very restless, and 'can't sit still' for any length of time
☐0 ☐1 ☐2 ☐3 ☐4
 Never Occasionally Sometimes Fairly often Very often
- 16 Finds it difficult to stop doing something even if s/he knows s/he shouldn't
☐0 ☐1 ☐2 ☐3 ☐4
 Never Occasionally Sometimes Fairly often Very often
- 17 Will say one thing, but will do something different
☐0 ☐1 ☐2 ☐3 ☐4
 Never Occasionally Sometimes Fairly often Very often
- 18 Finds it difficult to keep his/her mind on something, and is easily distracted
☐0 ☐1 ☐2 ☐3 ☐4
 Never Occasionally Sometimes Fairly often Very often
- 19 Has trouble making decisions, or deciding what s/he wants to do
☐0 ☐1 ☐2 ☐3 ☐4
 Never Occasionally Sometimes Fairly often Very often
- 20 Is unaware of, or unconcerned about, how others feel about his/her behaviour
☐0 ☐1 ☐2 ☐3 ☐4
 Never Occasionally Sometimes Fairly often Very often

**APPENDIX 8 – EXAMPLE OF BECK DEPRESSION INVENTORY
QUESTIONNAIRE (BDI-II)**

Name: _____ Marital Status: _____ Age: _____ Sex: _____

Occupation: _____ Education: _____

Instructions: This questionnaire consists of 21 groups of statements. Please read each group of statements carefully, and then pick out the **one statement** in each group that best describes the way you have been feeling during the **past two weeks, including today**. Circle the number beside the statement you have picked. If several statements in the group seem to apply equally well, circle the highest number for that group. Be sure that you do not choose more than one statement for any group, including Item 16 (Changes in Sleeping Pattern) or Item 18 (Changes in Appetite).

1. Sadness

- 0 I do not feel sad.
- 1 I feel sad much of the time.
- 2 I am sad all the time.
- 3 I am so sad or unhappy that I can't stand it.

2. Pessimism

- 0 I am not discouraged about my future.
- 1 I feel more discouraged about my future than I used to be.
- 2 I do not expect things to work out for me.
- 3 I feel my future is hopeless and will only get worse.

3. Past Failure

- 0 I do not feel like a failure.
- 1 I have failed more than I should have.
- 2 As I look back, I see a lot of failures.
- 3 I feel I am a total failure as a person.

4. Loss of Pleasure

- 0 I get as much pleasure as I ever did from the things I enjoy.
- 1 I don't enjoy things as much as I used to.
- 2 I get very little pleasure from the things I used to enjoy.
- 3 I can't get any pleasure from the things I used to enjoy.

5. Guilty Feelings

- 0 I don't feel particularly guilty.
- 1 I feel guilty over many things I have done or should have done.
- 2 I feel quite guilty most of the time.
- 3 I feel guilty all of the time.

6. Punishment Feelings

- 0 I don't feel I am being punished.
- 1 I feel I may be punished.
- 2 I expect to be punished.
- 3 I feel I am being punished.

7. Self-Dislike

- 0 I feel the same about myself as ever.
- 1 I have lost confidence in myself.
- 2 I am disappointed in myself.
- 3 I dislike myself.

8. Self-Criticalness

- 0 I don't criticize or blame myself more than usual.
- 1 I am more critical of myself than I used to be.
- 2 I criticize myself for all of my faults.
- 3 I blame myself for everything bad that happens.

9. Suicidal Thoughts or Wishes

- 0 I don't have any thoughts of killing myself.
- 1 I have thoughts of killing myself, but I would not carry them out.
- 2 I would like to kill myself.
- 3 I would kill myself if I had the chance.

10. Crying

- 0 I don't cry anymore than I used to.
- 1 I cry more than I used to.
- 2 I cry over every little thing.
- 3 I feel like crying, but I can't.

Subtotal Page 1

Continued on Back

11. Agitation

- 0 I am no more restless or wound up than usual.
- 1 I feel more restless or wound up than usual.
- 2 I am so restless or agitated that it's hard to stay still.
- 3 I am so restless or agitated that I have to keep moving or doing something.

12. Loss of Interest

- 0 I have not lost interest in other people or activities.
- 1 I am less interested in other people or things than before.
- 2 I have lost most of my interest in other people or things.
- 3 It's hard to get interested in anything.

13. Indecisiveness

- 0 I make decisions about as well as ever.
- 1 I find it more difficult to make decisions than usual.
- 2 I have much greater difficulty in making decisions than I used to.
- 3 I have trouble making any decisions.

14. Worthlessness

- 0 I do not feel I am worthless.
- 1 I don't consider myself as worthwhile and useful as I used to.
- 2 I feel more worthless as compared to other people.
- 3 I feel utterly worthless.

15. Loss of Energy

- 0 I have as much energy as ever.
- 1 I have less energy than I used to have.
- 2 I don't have enough energy to do very much.
- 3 I don't have enough energy to do anything.

16. Changes in Sleeping Pattern

- 0 I have not experienced any change in my sleeping pattern.
- 1a I sleep somewhat more than usual.
- 1b I sleep somewhat less than usual.
- 2a I sleep a lot more than usual.
- 2b I sleep a lot less than usual.
- 3a I sleep most of the day.
- 3b I wake up 1-2 hours early and can't get back to sleep.

17. Irritability

- 0 I am no more irritable than usual.
- 1 I am more irritable than usual.
- 2 I am much more irritable than usual.
- 3 I am irritable all the time.

18. Changes in Appetite

- 0 I have not experienced any change in my appetite.
- 1a My appetite is somewhat less than usual.
- 1b My appetite is somewhat greater than usual.
- 2a My appetite is much less than before.
- 2b My appetite is much greater than usual.
- 3a I have no appetite at all.
- 3b I crave food all the time.

19. Concentration Difficulty

- 0 I can concentrate as well as ever.
- 1 I can't concentrate as well as usual.
- 2 It's hard to keep my mind on anything for very long.
- 3 I find I can't concentrate on anything.

20. Tiredness or Fatigue

- 0 I am no more tired or fatigued than usual.
- 1 I get more tired or fatigued more easily than usual.
- 2 I am too tired or fatigued to do a lot of the things I used to do.
- 3 I am too tired or fatigued to do most of the things I used to do.

21. Loss of Interest in Sex

- 0 I have not noticed any recent change in my interest in sex.
- 1 I am less interested in sex than I used to be.
- 2 I am much less interested in sex now.
- 3 I have lost interest in sex completely.

APPENDIX 9 – PATIENT INFORMATION SHEET

Participant Information Sheet

Project title: Acquired impairments in 'theory of mind' and executive function following stroke

I would like to invite you to take part in a research project to enable us to learn more about people's experience following a stroke and how to help them more effectively.

Background

Sometimes after having a stroke a number of individuals have been reported experiencing some difficulties interacting with other people, even though they did not have these difficulties before their stroke. In addition, some individuals experience difficulties with tasks requiring, for example, problem solving and initiation. This is commonly referred to as executive functioning.

The purpose of this study is to investigate in more detail what social understanding difficulties people do experience after having a stroke (if any) and to see whether this has any effect on the way they behave.

What will I have to do?

This project involves looking at pictures and then stating how the person in the picture is thinking or feeling. You will also be asked to do a few short tasks and complete a couple of brief questionnaires. Altogether, it will take about 45 minutes to complete all parts of the study. The researcher Jackie Hamilton will explain the questionnaire and the tasks to you and will answer any questions you may have about the project.

Questionnaires

One of the questionnaires you will be asked to complete is designed to help identify individuals who are depressed. Depression is a complex condition, and scoring highly on this questionnaire does not necessarily mean that you are depressed. With your permission however, if you were found to score within the depressed range, it would be good practice for me to inform the Consultant in charge of your care.

Patient Notes

I would also like to request permission to review your file/notes for information e.g about the type of stroke you experienced. This information will be kept in the strictest confidence.

Do I have to take part?

No. Taking part is entirely voluntary. If you decide not to take part, you do not have to give a reason. Any treatment or support you receive will not be affected as a result of your decision. Similarly, if you agree to participate, I would also like to inform you that you are free to withdraw from this study at any time without having to give a reason. Again, this will not affect your ongoing care and treatment.

Confidentiality

All participant information gathered during this study will be anonymised, known only to the researcher, and will be kept strictly confidential.

Please turn over the page

APPENDIX 10 – CONTROL INFORMATION SHEET

Participant Information Sheet (control)

Project title: Acquired impairments in 'theory of mind' and executive function following stroke

I would like to invite you to take part in a research project to enable us to learn more about people's experience following a stroke and how to help them more effectively.

Background

Sometimes after having a stroke a number of individuals have been reported experiencing some difficulties interacting with other people, even though they did not have these difficulties before their stroke. In addition, some individuals experience difficulties with tasks requiring, for example, problem solving and initiation. This is commonly referred to as executive functioning.

The purpose of this study is to investigate in more detail what social understanding difficulties people do experience after having a stroke (if any) and to see whether this has any effect on the way they behave. **You have been invited to take part because you have not had a stroke.** Learning more about how people who have not had a stroke perform these tasks is also helpful.

What will I have to do?

This project involves looking at pictures and then stating how the person in the picture is thinking or feeling. You will also be asked to do a few short tasks and complete a couple of brief questionnaires. Altogether, it will take about 45 minutes to complete all parts of the study. The researcher Jackie Hamilton will explain the questionnaire and the tasks to you, and will answer any questions you may have about the project.

Questionnaires

One of the questionnaires you will be asked to complete is designed to help identify individuals who are depressed. Depression is a complex condition, and scoring highly on this questionnaire does not necessarily mean that you are depressed. However, if you were found to score within the depressed range, it would be good practice for me to advise you to consult with your General Practitioner.

Do I have to take part?

No. Taking part is entirely voluntary. If you decide not to take part, you do not have to give a reason. Similarly, if you agree to participate, I would also like to inform you that you are free to withdraw from this study at any time without having to give a reason. This will not affect possible future care or treatment.

Confidentiality

All participant information gathered during this study will be anonymised, known only to the researcher, and will be kept strictly confidential.

Please turn over the page

What to do now?

If you would like to take part in the study or would like more information, you can contact me directly at the address or telephone number below and I will be more than happy to talk to you further.

Thank you very much for considering taking part in this study. Please discuss this matter with your family and friends if you wish.

Jackie Hamilton
Trainee Clinical Psychologist
Dept of Neuropsychology
Wd 40, ARI

Tel: (01224) 554350
Secretary: (01224) 553451

Dr Fiona Summers
Clinical Neuropsychologist
Dept of Neuropsychology
Wd 40, ARI

Tel: (01224) 554350
Secretary: (01224) 553451

Should you have any concerns or complaints about the manner in which this research is being carried out, please contact Dr Fiona Summers at the above address, or speak to the principal researcher Jackie Hamilton directly.

APPENDIX 11 – CONSENT FORM

APPENDIX 12 – LETTER OF ETHICAL APPROVAL

APPENDIX 13 – CORRELATIONAL ANALYSES

CONSENT FORM

CONSENT BY PATIENT/VOLUNTEER TO PARTICIPATE IN: Research study approved by Grampian Ethics Committee

Name of patient/volunteer:
Acquired impairments in theory of mind
following stroke

Name of Study:
Jackie Hamilton

Principal Investigator:

I have read the patient/volunteer information sheet on the above study and have had the opportunity to discuss the details with and ask question. The principal investigator has explained to me the nature and purpose of the study and the tests to be undertaken. I understand fully what is proposed to be done.

I have agreed to take part in the study as it has been outlined to me, but I understand that I am completely free to withdraw from the study or any part of the study at any time I wish. I also understand that this will not affect my continuing medical treatment in any way.

I understand that the tests are part of a research project designed to promote psychological knowledge, which has been approved by the Grampian Research Ethics Committee, and may be of no benefit to me personally.

I hereby fully and freely consent to participate in the study which has been fully explained to me.

Signature of patient/volunteer:
Date:

I confirm that I have explained to the patient/volunteer named above, the nature and purpose of the tests to be undertaken.

Signature of investigator:
Date: